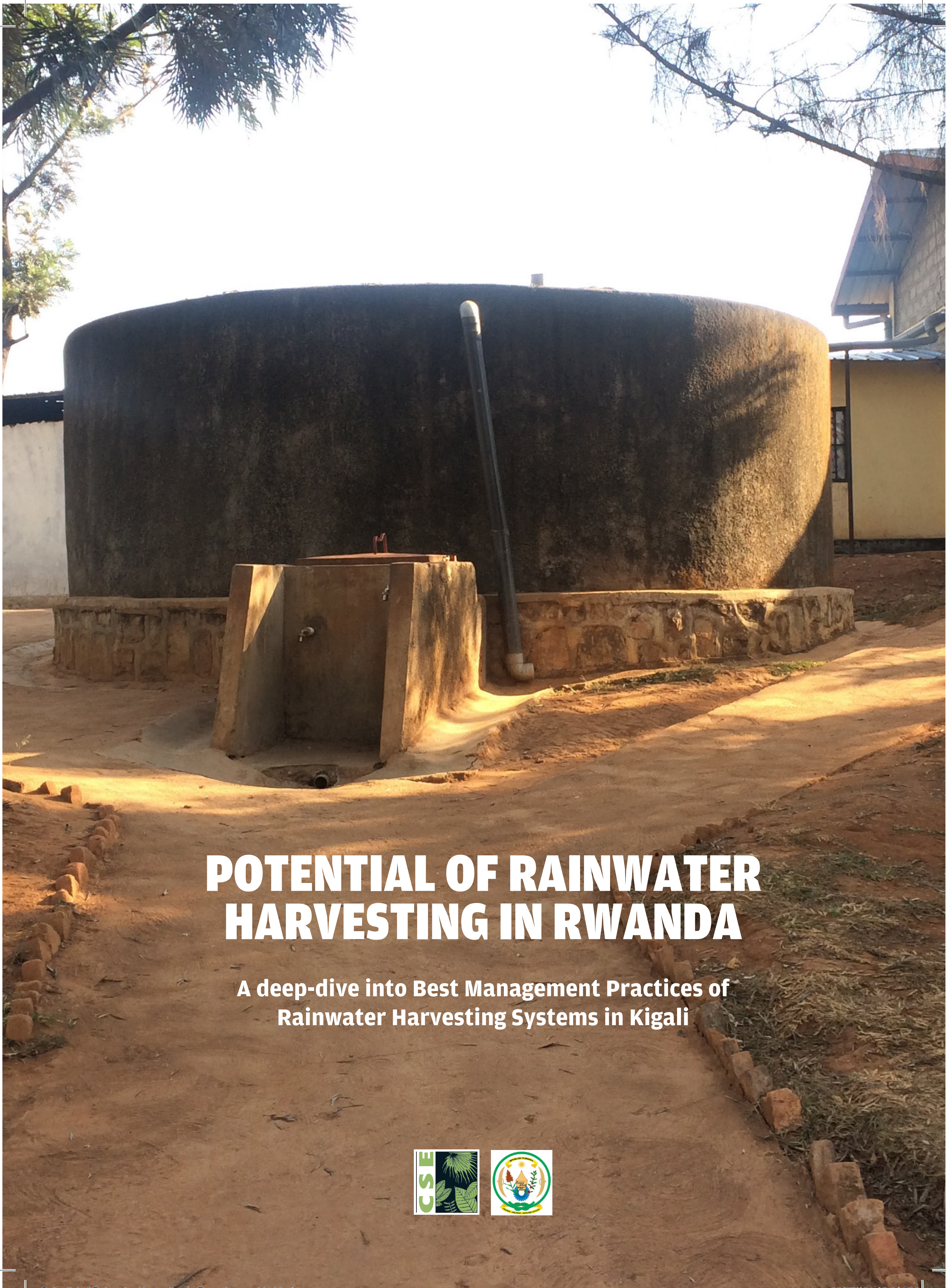

# POTENTIAL OF RAINWATER HARVESTING IN RWANDA

## A deep-dive into Best Management Practices of Rainwater Harvesting Systems in Kigali

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RWANDA WATER AND FORESTRY AUTHORITY (RWFA)

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## Abbreviations

| | |
|---|---|
| Best management practices | BMPs |
| Centre for Science and Environment | CSE |
| Forward-looking joint sector report | FLSP |
| High-density polyethylene | HDPE |
| Ministry of Infrastructure | MININFRA |
| Non-Revenue Water | NRW |
| National Institute of Statistics of Rwanda | NISR |
| Operation and maintenance | O&M |
| Polyvinyl chloride | PVC |
| Pipe penetrating radar | PPR |
| Rainwater Harvesting | RWH |
| Rwandan franc | RWF |
| Rwanda National Land use Development Master Plan | RNLUMP |
| Rwanda Utilities Regulatory Authority | RURA |
| Rwanda water and forestry authority | RWFA |
| Sustainable Development Goals | SDGs |
| Sustainable Urban Drainage Systems | SUDS |
| Urban local bodies | ULBs |
| Water and Sanitation Corporation | WASAC |
| Water treatment systems | WTPs |

# Executive Summary

According to the World Economic Forum's Global Risks Report 2018, water crisis is one of the most pressing threats perceived as having the biggest impact in the next 10 years. Across continents, natural water resources are becoming more strained each year with increasing urbanization. A similar trend is also observed in Rwanda which has one of the highest population densities in Africa (483 people/sq. Km). Its capital, Kigali is a major urban centre with 76% of the population categorized as 'urban'.

At the same time, Rwanda is also among the countries having the lowest per capita water availability (670m$^3$/capita/year) and storage capacity in Africa. Besides inadequate per-capita availability, floods accompanied with soil erosion are a common issue in Rwandan cities. Given its current scenario, there is a need to look into existing water supply and stormwater management scenario.

Despite these setbacks, Rwanda has a high potential of Rainwater Harvesting (RWH) with an annual average rainfall of 1200 mm with monthly consistency throughout the year. The national provisions like VISION 2020, Economic Development and Poverty Reduction Strategy highlight rainwater as the most feasible option for providing alternative source of water. However, RWH is not considered as an immediate response to the issue of water stress in the country. Considering its immense potential, RWH must be promoted as part of infrastructure development to achieve water augmentation and stormwater management.

This report documents the existing RWH best management practices to encourage diverse stakeholders on the potential of mainstreaming RWH and how it can contribute to sustainable water management. It focuses on high visibility and high impact urban RWH interventions / case studies at various levels like institutional buildings, or other key buildings—schools, hotels or industries in Kigali. This document also highlights challenges related to sustainable implementation and functioning of RWH in Kigali in various sectors i.e. legal, social, economic and environmental. Furthermore, potential solutions to overcome these challenges are suggested, supported by interviews of various stakeholders.

In the following pages, we have attempted to develop a roadmap which is based on water sensitive design approach defining the strategies required to scale up RWH in a holistic and sustainable manner involving collaboration/partnership with all the relevant stakeholders through various approaches. An approach like RWH isn't just a viable alternative to current practices, it also aligns with the 2030 SDGs, which include clean water, sanitation and sustainable cities, with community involvement.

# 1 Introduction

## 1.1 Rationale for assessing RWH potential in Rwanda

Water is one of the most essential natural resources for human survival, which plays a major role in the socio-economic development of any given country. With a current population of over 12.6 million people spread over 26,338 $km^2$, Rwanda is Africa's most densely populated country. The urban population of Rwanda is increasing rapidly, as well; socio-economic life is improving. Water demand for satisfying the needs in municipal sector is increasing. The high water demand together with manmade activities are causing numerous water resource challenges in terms of overall water management.[1]

Rwanda is committed to ensure the availability and sustainable management of water and sanitation for all by 2030. Goal 6 of the Sustainable Development Goals (SDGs) states that it is essential to optimize water demand management activities by solving the water resources challenges.[2]

However, the current water supply system in the country is hampered by various issues, including high pumping cost for distribution due to hilly terrain, hence high electricity cost to maintain the water supply infrastructure, low water supply coverage, low water production and high non-revenue water.

In the city of Kigali (CoK), capital of Rwanda, where the majority of the country's urban residents reside, access to municipal water constitutes a critical issue with long length of the water supply distribution network of 2,080 km. Even for the proportion of households currently connected to the piped network, water provision is uncertain due to regular interruptions. The residents who are not connected to the piped network at all face higher average water costs and are generally even poorer than connected residents.[3,4]

The combined stress of sustained economic development, population growth, urbanization and climate change mean an improved, integrated approach to water management is required to ensure Rwanda's water resources are equitably, efficiently and sustainably used.[5]

Although Rwanda receives relatively high annual average rainfall of 1200 mm,[6] the rainwater is not used to its full potential. Instead, the country is often perceived to be susceptible to increased erosion, flooding and drought due to high rainfall intensity.

In urban Rwanda, mainly in CoK, heavy rainfall events cause rapid surges in the flow of rivers and drainage systems leading to floods downstream. The flash floods are observed mainly in areas where the rapid urbanization of hill slopes has dramatically increased the runoff water.[7] In addition, inadequate drainage systems and constructions in flood-prone zones have made many neighbourhoods of CoK highly susceptible to flooding and erosion.[8]

The need of the hour is to recognize the importance of sustainable urban drainage systems (SUDS) and urban green spaces in creating a naturally-oriented water cycle while contributing to the amenity of the city. This will be achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilient and adaptive measures to deal with the eventualities of floods.

To control this water resources exploitation, there is a need of an approach of Water-sensitive urban design and planning (WSUDP) that integrates the urban water cycle, water supply, storm-water and groundwater management with spatial and urban design. This report assesses the factors that influence the rainwater use as one of the water resources under urban water augmentation and stormwater management of Rwanda.

### 1.2 The need for a paradigm shift and new approach

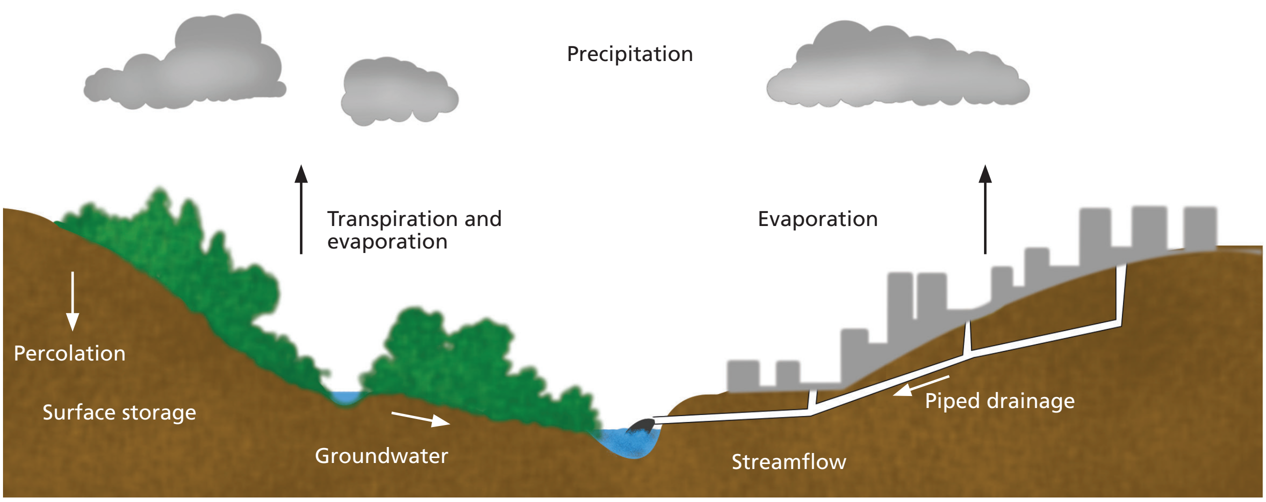
It can be concluded that the high percentage of impervious surfaces in urban areas alters runoff and drainage patterns, making natural events of rain an enabling pathway for oil, grease, toxins, pathogens, nutrients, and other pollutants to reach nearby waterways. Storm flows of high volume and velocity cause additional adverse environmental consequences, such as flooding and riparian habitat loss. Impervious surfaces prevent rainwater from seeping into the ground, thereby preventing groundwater recharge. This results in degradation and depletion of water bodies and groundwater resources in urban areas (see Figure 1.1).

The altered hydrology causes environmental impacts, including downstream flooding, stream-bank erosion and stream down cutting, deteriorating water quality due to increase in sediment, nutrients and heavy metals, and a decline in aquatic biota.

Urban development can, however, be planned and executed so as to lower the hydrological impact of urbanization by using current opportunities to increase the carrying capacity of the area in terms of improved water management. WSUDP, being the integrated design of the urban water cycle, incorporating water supply, wastewater, storm-water and groundwater management, urban design and environmental protection, can contribute towards sustainability and liveability, particularly when considered as part of an overall urban strategy

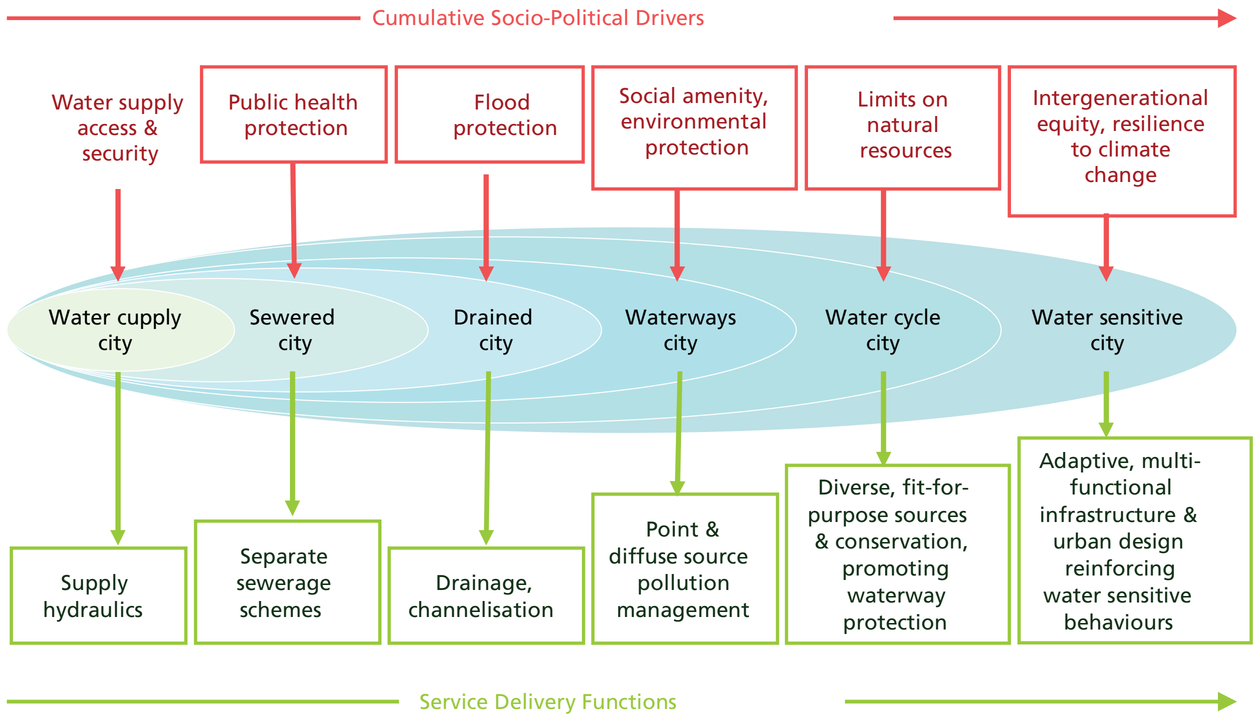
WSUDP has been identified as a means to control flows and filter storm water to remove pollutants. It offers the potential to reduce the costs, infrastructure sizing and occupied land area associated with conventional drainage approaches

**Figure 1.1: Comparison between natural and urban hydrological cycles**




*Source: Girling, C. and Kellett, R., 2005. Skinny streets and green neighborhoods: design for environment and community. Island Press.*

**Figure 1.2: Urban water management transition framework**




*Source: Brown, R., Keath, N. and Wong, T., 2008, August. Transitioning to Water Sensitive Cities: Historical, Current and Future Transition States. In 11th International Conference on Urban Drainage (Vol. 10).*

whilst treating runoff closer to its source. This approach if adopted in cities of Rwanda would help in accessing the potential of water quantity on-site, comprising runoff, groundwater, wastewater and floodwater. This would lead to gradual transition from water supply city to water sensitive city. Sustainable water management requires a holistic approach toward sustainability along with prudent use of water resources. Figure 1.2: *Urban water management transition framework* shows the evolution in planning and designing of cities and their water management.

## 1.3 Objectives and scope of work

Centre for Science and Environment (CSE), a New Delhi (India) based global think tank has more than three decade known experience in conducting and implementing extensive research and capacity-building programmes on sustainable water management. The centre has been recognized as a nodal hub for developing and establishing principles, innovative technologies and implementation strategies for water and wastewater management in order to help lay the foundations for a water and waste-prudent society.

CSE believes this experience needs to be leveraged to share solutions with other countries in the developing world from Africa and Asia to meet the needs of urban populations in the current water and wastewater paradigm, which are affordable and sustainable. The aim is to develop a network of South-South researchers, practitioners, regulators and other stakeholders involved in advocacy for balanced environment and development of mainstreaming sustainable water management.

Since 2016, CSE is working in Rwanda in the area of sustainable water management in partnership with Ministry of Infrastructure (MININFRA), Rwanda Water and Forestry Authority (RWFA) and WaterAid. Under this initiative, CSE has conducted a series of need-based trainings on water management catering to more than 200 state and non-state practitioners (engineers, consultants, architects, planners and academicians) in Kigali, Rwanda. The aim of such trainings is to develop a cadre of practitioners in the area of sustainable water management. CSE also gave inputs in the National RWH strategy document (Draft) to RWFA.

In order to understand and scale up the RWH in urban areas of Rwanda, CSE initiated this report, which accesses the existing framework and practices involved in implementing RWH in CoK. Through this report, strategies and enabling environment to upscale RWH will be provided. The study area of this research document is the urban area of the CoK thus in the coming sections the focus will be centred on Kigali.

The aim of the report is to assess the applicability of RWH as one of the potential measures for sustainable water management in urban areas of Rwanda.

The structure of the report is as follows:

***Objective 1**: To evaluate the potential and scope of RWH system implementation for urban water management in Rwanda.*

Chapters 1 and 2 define this objective. Chapter 1 sets the context for the report. It defines objectives of the report and methodology used to prepare it. It demarcates the relevant users and benefits of using the report.

Chapter 2 describes the city profile of Kigali in terms of regional setting, demographic, land use. The chapter also discribes the water supply and stormwater management.

***Objective 2:** To assess the RWH system implemented at various scales in the city of Kigali*

Chapter 4 provides a detailed analysis of various RWH intervention in Kigali using the data collected from site visits and interviewing the stakeholders benefited/involved in the implementation of RWH systems. The case studies were reviewed in terms of socio-economic and environment benefits.

***Objective 3:** To provide improved understanding about the concept of water sensitive approach*

Chapter 4 focuses on the concept and methodology of RWH at city/zonal and individual scale. This chapter also brings into focus stormwater management through SUDS.

***Objective 4:** To analyse the sustainability of existing RWH system interventions in the context of urban areas of Rwanda*

***Objective 5:** To provide strategies to stakeholders for creating an enabling environment for upscaling RWH in urban areas of Rwanda.*

Chapter 5 covers the objectives 4 and 5. The chapter discusses in detail the challenges faced pertaining to implementation of RWH in the CoK in various sectors i.e. legal, social, economic, environmental and future sustainability (including operation and maintenance). It further suggests the potential solutions to overcome these challenges supported by interviews of various stakeholders. It also defines the strategies required to scale up urban RWH in a holistic and sustainable manner involving collaboration/partnership with all the relevant stakeholder and through various approaches.

## 1.4 Methodology of the report

*Research Hypotheses: Upscaling RWH could be a sustainable way of solving or alleviating the water related challenges in urban areas of Rwanda*

Research Question 1: What are the challenges and opportunities in upscaling RWH in urban areas of Rwanda to address the water management issues?

*Research Objective* 1: To understand the water management challenges in urban areas of Rwanda

Research Question 2: Is there enough political and regulatory push to support adoption of RWH in the country? What are they?

*Research Objective* 2: To highlight the policies, missions and major initiatives that facilitate adoption of RWH in Rwanda.

Research Question 3: What are the financial barriers that prevent adoption of RWH?

*Research Objective* 3: To analyse the existing subsidy and incentive structure in the water governance for supporting RWH.

Research Question 4: Are there enough benefits at user level to adopt RWH?

*Research Objective* 4: To determine the interest of users in installing RWH systems at private premises.

Research Question 5: What could be the elements of an enabling environment to support upscaling RWH at a country level?

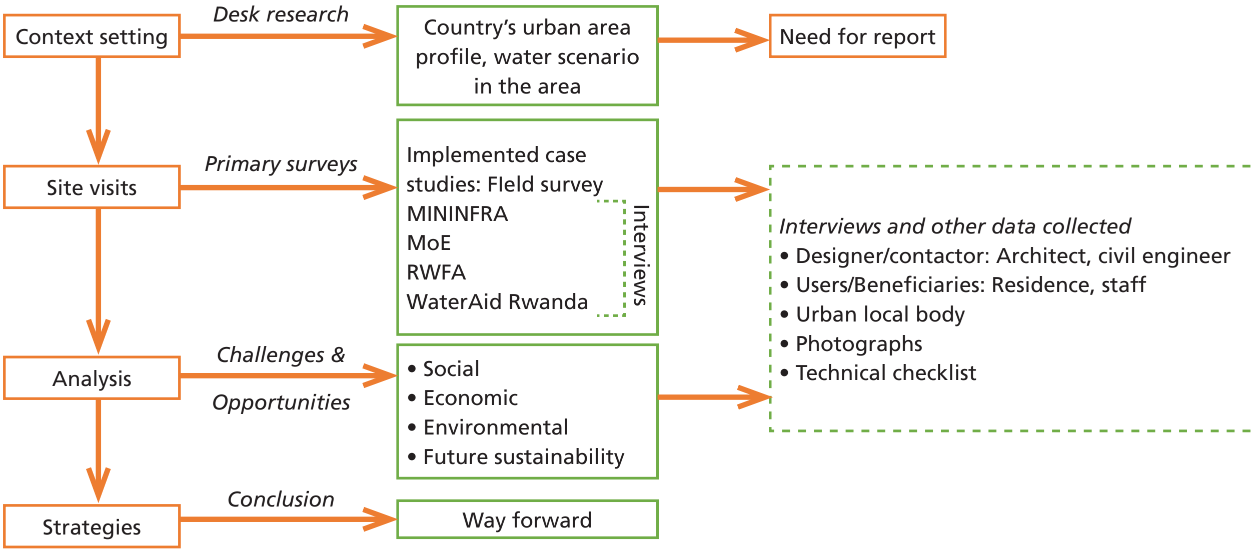
*Research Objective* 5a: To understand the sustainability paradigm for upscaling RWH initiative, such as social, political, economic, environmental and regulatory dimensions.

*Research Objective* 5b: To identify the roles and responsibilities of various stakeholders in making the initiative a success.

Note: *Research Methodologies for all the above questions are primary research, case study analysis and secondary research (interviews, media stories etc.)*

1. **Primary research:** Best management practices (BMPs) in CoK for RWH systems were identified and shortlisted. A detailed checklist related to technical, socio-economic and environmental data was used to analyse the BMPs (see Figure 1.1). Further key informant interviews (KII) and focus group discussions (FGD) of the beneficiaries and other stakeholders (e.g. municipal functionaries, architects, beneficiaries, NGOs, consultants, etc

**Figure 1.1: Research methodology of the report**




*Source: CSE, 2018*

details provided in annexure1) was carried out. The BMPs were classified on the basis of the following criteria:

- o Type of building: schools, public and semi-public landuse, small scale industries and hotel, neighbourhood/housing societies
- o Area range: 1,000 sqm to 15,000 sqm
- o Number of users: 10 to 4,000

2. **Secondary research:** Desk research was done to understand the profile of CoK in terms of its regional setting, demography, land use pattern, hydrology, climate, rainfall, water resources & supply, stormwater management. Further concepts and methods of RWH at individual, city and zonal scale were studied.

3. **Qualitative and quantitative analysis:** To understand the impact of RWH intervention, analysis was conducted using the data collected from site visits and various KII and FGD with the key stakeholders. The challenges and opportunities were identified in terms of legal, social, environment, economic and sustainability of any such intervention in context of urban areas of Rwanda. In addition, a roundtable meeting was held in which experts and all the stakeholders across Rwanda were invited to share knowledge and give inputs, recommendations and suggestions for the draft report (refer to annexure 2). Further analysis of the existing policies, programmes and plan in water sector was done (annexure 3 and 4). This helped in setting the context and making the case for the need for RWH.

4. **Roadmap design for RWH:** From the above findings of sector specific issues, strategies have been suggested for creating demand, funding, capacity building, etc for effective sustainability of the projects. If the suggested strategies are followed diligently then it would help in creating an enabling environment for implementing RWH.

## Table 1.1: Stakeholder participation in RWH planning and implementation

| Stakeholder | Role and responsibility |
|---|---|
| Implementer | • Updated knowledge of RWH systems and skill of implementing the technology |
| Beneficiary/ community | • Aware of the benefits of RWH<br>• Acquainted with O&M component of RWH intervention<br>• Involved in decision making |
| Decision makers | • Provide/establish RWH bylaws, regulations, guidelines, policies, norms<br>• Initiate/provide schemes on subsidy and incentives of RWH systems<br>• Facilitate capacity building programmes of technical and non-technical staff |
| Consultant | • Provide information on feasibility and techniques of RWH<br>• Help policy makers in drafting policies, strategies, etc on RWH |
| Researcher and training institutes | • Provide necessary information on the concept and methods of RWH interventions<br>• Sensitization and capacitate various stakeholders on RWH<br>• Research on feasibility of RWH in terms of environment and health implications<br>• Research and dissemination of knowledge on BMPs of RWH implemented in other countries<br>• Provide course curriculum on RWH |
| Funding agencies and CSR | • Provide necessary funds for research and implementing of RWH structures<br>• Promote monitoring and future impact of the implemented system with the component of funding for the same |
| NGOs | • Help decision makers in drafting policies, strategies on RWH<br>• Capacitate relevant stakeholders on RWH techniques and its sustainability<br>• Awareness generation on RWH |
| Media | • To sensitize the general public towards sustainable water management and importance of RWH |

*Source: CSE, 2018*

## Table 1.2: Recommended target users

| Target group | The report will help to |
|---|---|
| • Ministry of Infrastructure (MININFRA)<br>• Ministry of Environment<br>• Rwanda water and forest authority (RWFA)<br>• Ministry of Forest<br>• Ministry of Disaster Management and Refugees Affairs<br>• Ministry of Local Government<br>• Water and Sanitation Corporation (WASAC)<br>• City of Kigali<br>• Rwanda Housing Authority | • Identify issues and opportunities related to sustainable water management which will feed into various national/regional documents<br>• Establish/facilitate skill development trainings to technical and non-technical staff<br>• To engage/partner with private sector/external donors to invest in implementation of RWH interventions<br>• Develop/enforce sector policies, laws, strategies and programs related to sustainable water management or specifically on RWH<br>• Monitor and assess the implementation and mainstreaming of policies, plan, programme, laws and RWH interventions towards sustainability of water management<br>• Conduct research on technologies, BMPs, case studies of RWH systems |
| Ministry of Health | • Research on effect of using harvested rainwater on human health |
| Ministry of Education | • Inclusion of RWH in course curriculum of schools and institutes for upscaling the benefits of RWH in the society |
| Researchers and Institutes | • Impart trainings and conduct research on the potential of RWH in Rwanda<br>• Provide technical support |
| NGOs and Consultants | • Comprehend the current scenario of RWH<br>• Focus on sensitization and advocacy of RWH<br>• Partner with government and non-government organisation for RWH interventions |
| Funding agencies | • Identify stakeholders for investment and development |

*Source: CSE, 2018*

### Stakeholder involvement

Multi-stakeholder participation is an essential component of planning and implementation of RWH systems. It helps in making the system more efficient and robust (See Table 1.1). A holistic planning approach on RWH should involve a strategy to combine the knowledge of all the relevant stakeholders.

However, for this report all the above stakeholders may not be the relevant target groups. Nevertheless, they may be part of the strategy meeting. The target groups for whom the report will be useful in context of Rwanda are listed in Table 1.2.

**Target group of the report**: The target audience for this guide comprises city officials from urban local bodies (ULBs) and development authorities such as urban planners, architects and landscape architects, town planning officers, engineers, and others involved in preparing and enforcing regional and master plans, zonal plans, city development plans and city sanitation plans and other local design standards, based on the involvement in the formulation and evaluation of RWH implementation strategies, provides an overview of the major user groups.

# 2 About Rwanda

Rwanda is a sovereign (and landlocked) country in central Africa with a varied geography covering roughly 25,000 $km^2$ of land and 1,400 $km^2$ of water.[9,10] Rwanda is characterized by a hilly terrain, with a physiographic pattern of steep hills, hence named as the 'Land of a Thousand Hills', a term that briefly illustrates Rwanda's high altitudes. Most of Rwanda is at least 900m above sea level; the central plains have an average elevation of 1932m, while South-Eastern Rwanda has a desert like terrain. Major rock types observed in the country are granitic gneiss, quartzite, schists and amphibolite. The soils of the top of the mountains are products of granite and gneiss and have resisted erosion. River banks are composed of alluvial and pluvial loose-fragmental soils as result of the erosion. About 40% of Rwanda's land is classified as having a very high erosion risk with about 37% requiring soil retention measures before cultivation.[11]

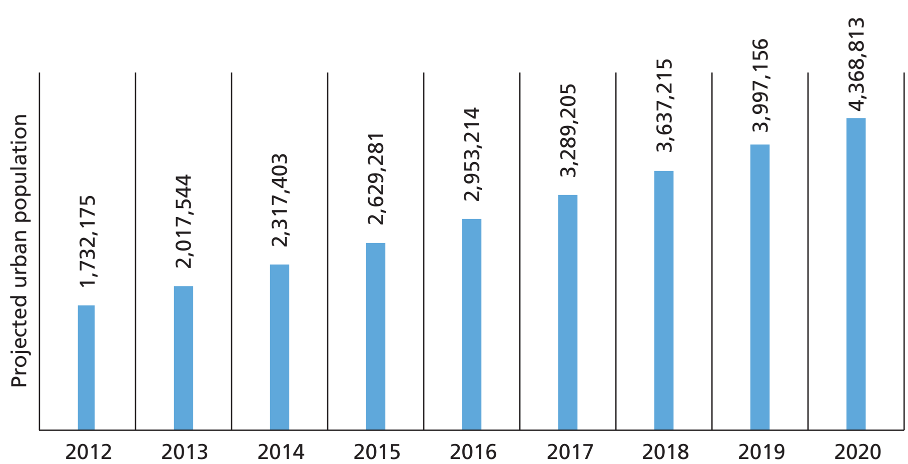
## 2.1 Urbanization trend

Rwanda is one of the most densely populated countries of Africa. As per 2012 census, Rwanda had approximately 12 million citizens and an annual population growth of 2.6%. Around 19.4% of the total inhabitants live in urban areas. Although Rwanda remains predominantly rural, the country has one of the fastest growing urbanization rates (app. 4.5% annually) in the world. Only five other countries in the world hold a higher rate of urbanization (Madagascar: 4.7%, Niger: 4.9%, Eritrea: 5.0%, Uganda: 5.7%, and Burkina Faso: 6.0%).[12]

In Rwanda, the country's urban population is expected to increase from 16.5% in 2012 to 30% in 2032, this means that 1.7 million of population in 2012 to 4.9 million of population in 2032 will be part of urban settlements (see Figure 2.1).[13,14]

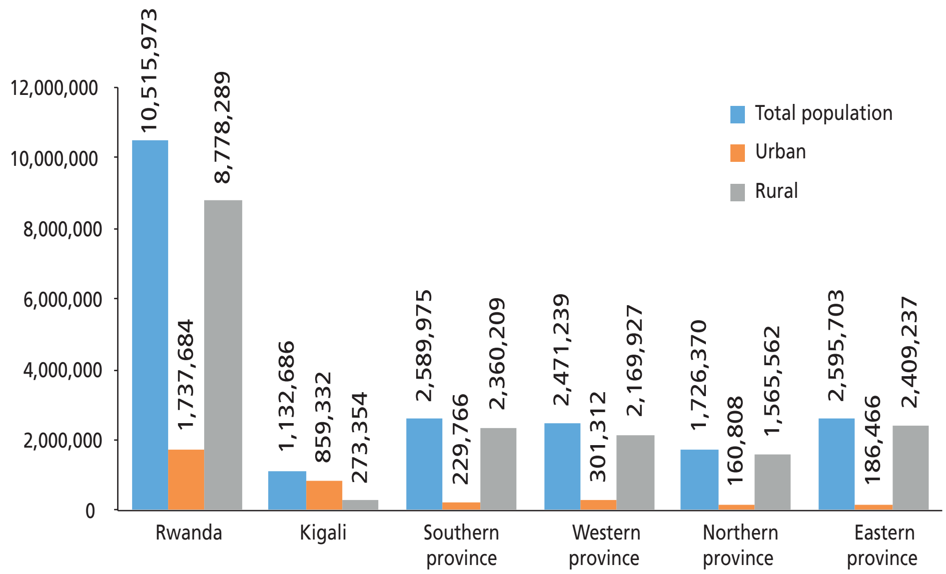
Around 76% of the urban population of Rwanda resides in CoK followed by inhabitants of western province with a proportion of only 12% people living in

**Figure 2.1: Urban population growth in Rwanda**



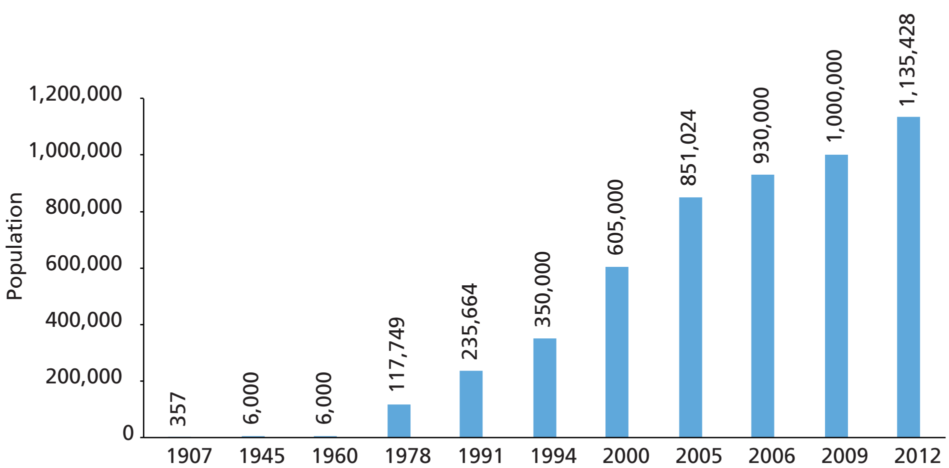

*Source: Rwanda 4th Population and Housing Census, 2012 (NISR)*

**Figure 2.2: Urbanization in Rwanda**




*Source: Rwanda 4th Population and Housing Census, 2012 (NISR)*

**Figure 2.3: Urban population growth, CoK**




*Source: Nduwayezu et al., 2016 Modelling urban growth in CoK Rwanda*

urban area, and the extend of population living in urban areas for the remaining provinces are between 7% and 9% (see Figure 2.2).[15]

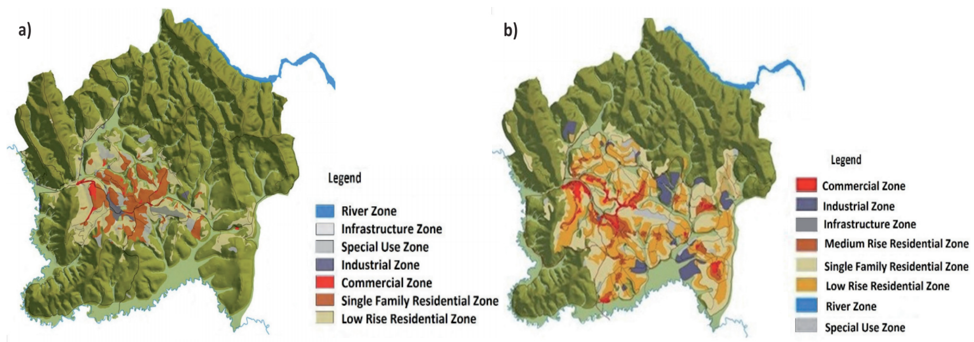
CoK is built on hilly landscape sprawling across four ridges, separated by large valley in between. It is subdivided into three districts, Gasabo, Kicukiro and Nyarugenge. These 3 districts have 35 sectors, subdivided into 161 cells.[16] With an annual growth rate of more than 4%, the city plans to increase investments in service delivery to meet the needs of a growing urban population (see Figure 2.3).[17]

### Landuse in CoK

In CoK, the share of urban area is around 17% (124.27 km$^2$), whereas the rural portion dominates with 83% coverage (606.73 km$^2$). The city is provided with many growth opportunities in terms of available undeveloped land and low-density areas with the potential to be developed. The city's current land use is

**Figure 2.4: Landuse plan of CoK**

***a) Existing landuse plan*** ***b) Proposed landuse plan 2040***




*Source: CoK: Master plan report 2013*

dominated by agriculture (63.10%), natural areas (19.40%), and residential areas (9.20%) (see Figure 2.4) whereas the projected future land use distributions for 2040 will be dominated by residential (43%), open and natural areas (26 %), industry (5%), and commercial and mixed use (3%).[18]

**Key points for urbanization trend in Rwanda**

- The annual population growth rate of Rwanda is 2.6%
- Rwanda has one of the fast growing urbanization rates of app. 4.5% annually in the world
- Country's urban population is expected to increase from 16.5% in 2012 to 30% in 2032
- Around 76% of urban population of Rwanda resides in CoK
- In CoK, the share of urban area is around 17%, whereas the rural portion is 83%
- Projected future land use distributions for 2040 will be dominated by residential 43%

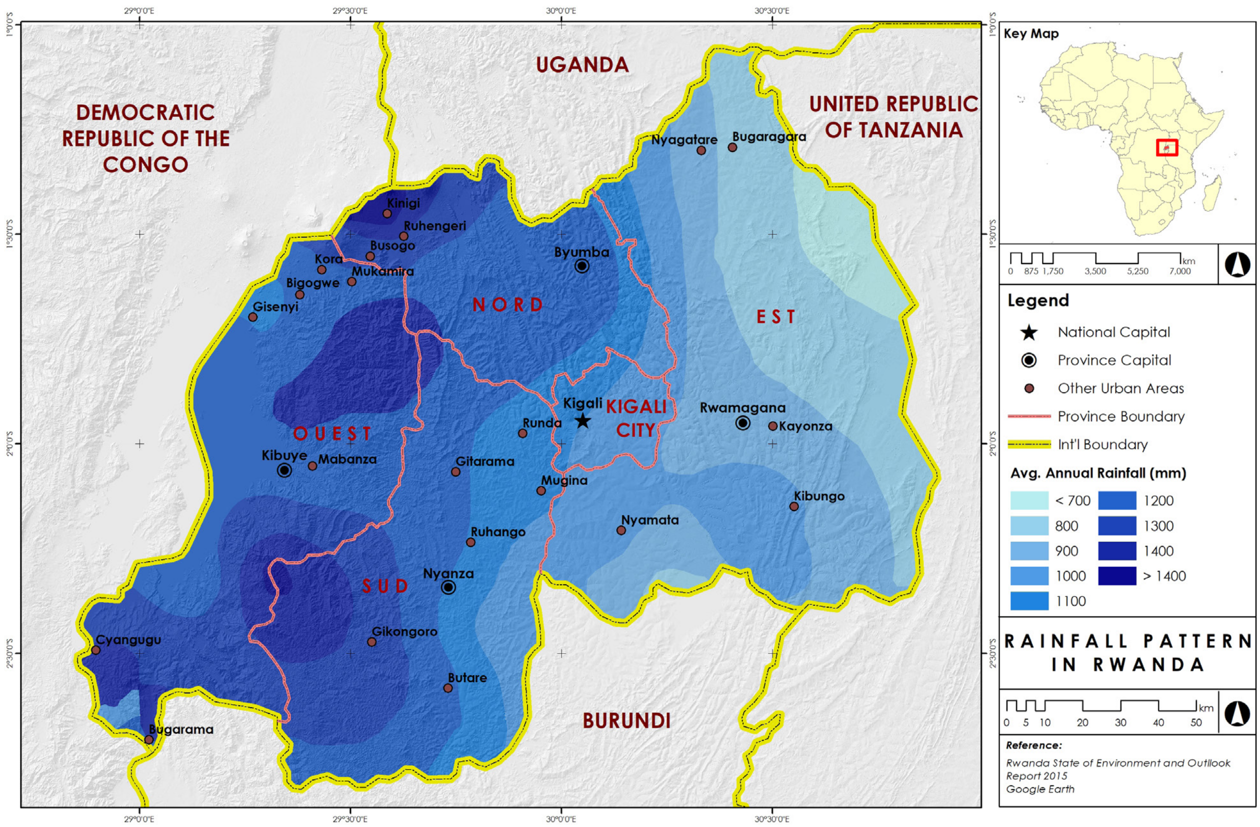
## 2.2 Precipitation

Although Rwanda is located only two degrees south of the equator, the country's high elevation makes the climate temperate. It is characterized by a humid tropical climate with average daily temperature of 22.8 °C at an altitude (near lake Kivu) of 1,463 m.
The country receives average annual precipitation of 1200mm and the rainfall ranges from as low as 800 mm in Eastern Province to about 2000mm in high altitude of north and west (see Map 1).

Rwanda has two main rainy seasons, a short rainy season (mid-September to mid-December) locally known as 'Umuhindo' which is characterized by a high precipitation in November and a long rainy season (March to May) locally known as 'Itumba', which is characterized by higher precipitation in April compared to that in November (Table 2.1).[19]

CoK with altitude of 1,567m experiences a long rainy season that extends from mid-February to mid-May with another rainy season from mid-September to mid-December. The rainy season may extend for some weeks into the dry season and vice versa. In general, the average precipitations range from 65 mm to 200 mm per month (see Figure 2.4).[20]

### Map 2.1: Rainfall pattern in Rwanda




*Source: Prepared by CSE*

### Table 2.1: Temporal distribution of rainfall

| Period | Season description | Share of Total Annual rainfall |
|---|---|---|
| Feb – May | Long rains (April is the wettest month) | 48% |
| June – Mid-Sept. | Long dry spell | Very little rains (25-50 mm especially in High altitude areas |
| Mid-Sept – Dec. | Short rains (November the wettest during this season) | 30% |
| Dec. – Jan. | Short rains with short dry spell | 22% |

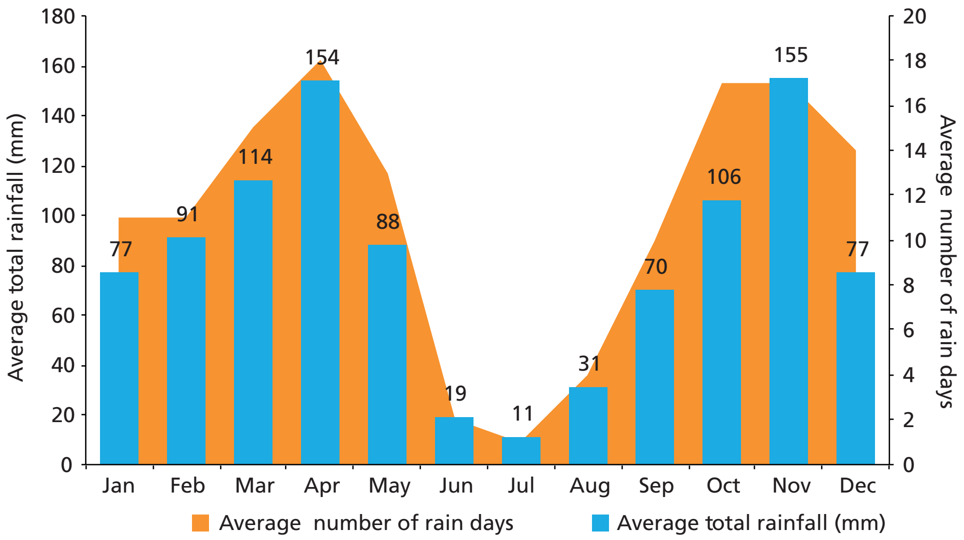
*Source: Water Resources Management Sub-Sector Strategic Plan (2011 – 2015)*

In times of extreme storms and rainfall, there can be a danger of flooding in the city, especially where urban developments have created impervious surfaces or changed hydrological conditions in rivers. Kigali, is one of the major flood prone areas in the country, where almost every year flood events are recorded.[21]

**Key points for precipitation as a resource in Rwanda**

- The country has a high potential to use rainwater as resource, it receives average annual precipitation of 1200mm (ranging 800mm in Eastern Province to about 2000mm in high altitude)
- Rwanda has two main rainy seasons, short (mid-September to mid-December) and long (mid-February to mid-May), this bimodal rainfall pattern has the potential to meet the storage demand throughout the year depending on the catchment conditions

**Figure 2.5: Rainfall pattern, CoK**




*Source: SOE 2013*

## 2.3 Water supply management in urban Rwanda

In Rwanda the major source of water supply is from surface water supplied from two major drainage basins: The Nile Basin to the east covering 67% of the surface area and delivering 90% of the national waters. While Congo Basin to the west covers remaining 33% of surface area and 10% of all national waters.[22] Surface water bodies in the country occupy a total of 135,000 Ha or about 8% of the country's surface area.[23] The country comprises of 101 lakes, and a network of disconnected 860 wetlands and 861 rivers.[24]

The ground water in urban areas contributes to the minimal part of the overall water supply source and is extracted from shallow aquifers situated in flood plains. Currently, there is not enough information to assess the groundwater resources in Rwanda in terms of total volume available, water levels, essential water quality parameters, etc. Most aquifers in Rwanda are found in fractured rocks with the exception of lava regions and in south west where complex aquifers can be found. As of 2009, there were at least 400 boreholes and wells in various parts of the country.[25]

Due to the hilly terrain of Rwanda, the groundwater depth varies from 10m in shallow aquifers to as deep as 200m in areas like Bugesera. Hence, the cost of drilling is high and can go up to 50 million RWF. In order to ensure a sustainable and rational water use, a Ministerial Order Nº002/16.01 of 24/05/2013 determining the procedure for declaration, authorization and concession for the utilizations of water was put in place, which states that the abstraction of water resources for any activity like irrigation, hydropower, fish farming, mining other than domestic activities, has to have a permit to use. As per KII with RWFA official, around 51 similar requests have been received from WASAC for their source of water treatment plants.[26,27]

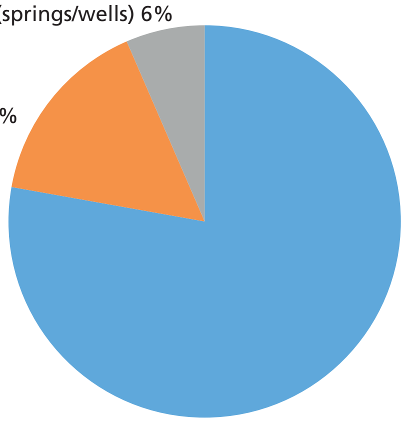
The major water supply source for CoK is from rivers and lakes constituting the four water treatment systems (WTPs) namely Nzove, Karenge and Kimisagara,

**Table 2.2: Overview of water supply systems, CoK**

| Water source | Raw water source | Production (m³/d) | Pipe length (km) |
|---|---|---|---|
| Nzove and Nzove II WTP | Nyabarongo river | 41,265 | 105.4 |
| Karenge WTP | Lake Mugesera | 12,826 | 69.5 |
| Kimisagara WTP | Yanze river | 22,347 | 23.7 |
| Others (Spring 5; Well 2) | | 5,317 | |
| Total | | 81,755 | |

*Source: Compiled by CSE, 2019*

**Figure 2.6: Types of water sources, CoK**




*Source: Planning for resilience in east Africa through policy, adaptation, research, and economic development USAID, 2014*

and the upcoming Kanzenze. In addition to this, there are seven well-maintained small-scale water sources using spring water, lake Mugesera and the Yanze river, as well as groundwater (See Table 2.2 and Figure 2.6). Some are distributed to city piping networks and some are supplied to independent water distribution sectors.[28]

Currently, three water treatment plants (Nzove, Karenge, and Kimisagara) are running in CoK. Construction of Nzove II water treatment plant was completed in March 2016, thus water production capacity in CoK has increased from 63,600 to 82,000 $m^3$/d. In addition, Kigali Bulk Water Project, Nzove II project and New Nzove I project are in progress for expansion of water treatment capacity in CoK. Thus the city will secure water production capacity of 167,000 $m^3$/d by 2020.[29]

CoK has developed in areas of hilly terrain which makes it difficult to construct an appropriate distribution reservoir location and water supply network utilizing gravity potential. Hence, all of these water source facilities are using water-powered driving equipment such as submersible pumps and water pumps during water intake or water distribution process. However, the percentage and cost of electricity component in water supply is not shared in public domain.

The water supply sub-sector context in Rwanda has changed considerably since the adoption of the 2010 National Policy and Strategy for Water Supply and Sanitation Services, which set the target of 100 per cent coverage of rural and urban water supply.[30] The main implementing agency for the water supply sub-sector is now Water and Sanitation Corporation (WASAC), a public utility

**Table 2.3: Existing institutional framework for water sector, Rwanda**

| Policy and oversight institutions | Financing institutions | Regulatory institutions | Management/service institutions |
|---|---|---|---|
| MININFRA; Ministry of Environment; Ministry of Local Government; Ministry of Finance and Economic Planning; Ministry of Health; Ministry of Agriculture, Animal Resources and affiliated agencies; Ministry of Education; Ministry of Commerce and affiliated agencies; Ministry of Foreign Affairs and Cooperation; Ministry of Disaster Management and Refugee Affairs; Ministry of Defence | Ministry of Finance; Planning and Economic Development; Development partners | RURA; Rwanda Environment Management Authority (REMA); Rwanda Bureau of Standards (RBS); RWFA | WASAC; Rwanda Development Board; District (WATSAN); Private Sector; NGOs; user communities |

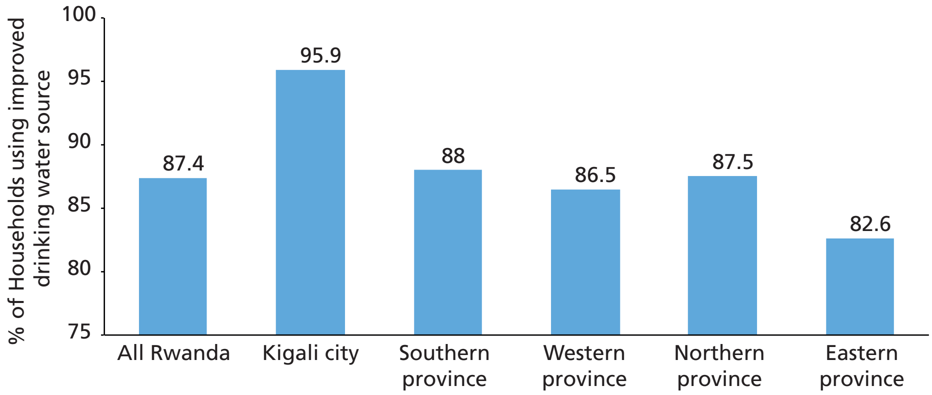
*Source: Aboniyo J. et al., 2017 National Water Resources Management Authority for a Sustainable Water Use in Rwanda*

that is licensed to operate and manage water treatment plants and distribution networks within urban and peri-urban areas. WASAC is, therefore, the key implementer of the policies and strategic plans related to water and sanitation, under the oversight of MININFRA and regulation by Rwanda Utilities Regulatory Authority (RURA).

Rwanda's water sector is governed under a complex institutional framework (see Table 2.3). The institutions are categorized into policy and oversight institutions, management and implementation institutions, service provision institutions and regulatory institutions. The institutional framework operates through the sectorwide approach, which applies in the planning and budgeting processes.[31]

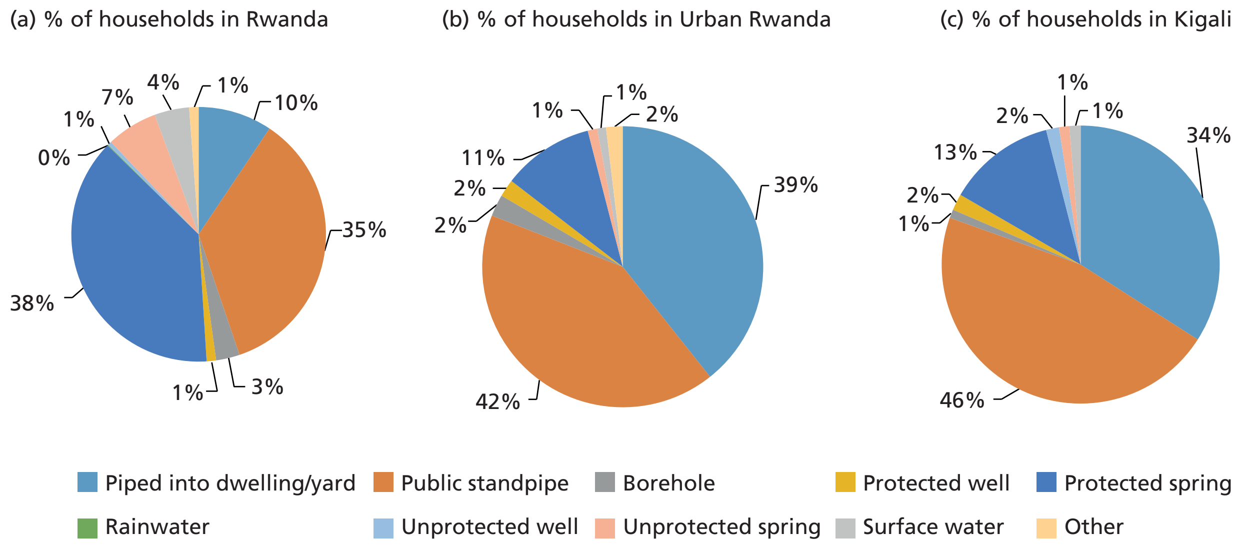
According to the Population and Housing Census, Rwanda, 2012 public tap out of the compound, pipe-born water in the compound and protected spring/ well are defined as sources of water supply in urban areas.[32] As per the latest Integrated Household Living Conditions Survey; EICV 5 conducted by National Institute of Statistics of Rwanda (NISR), at national level there has been an increase of 87% of households whose main source of water is an improved source. At provincial level, Kigali city ranks first with the highest percentage of households (96%) using improved water sources. By contrast the Eastern Province ranks fifth with the least percentage of using improved water sources. While in the North its 87.5%, West 86.5% and in the South 88%.[33] As per international definition, an improved water source includes protected springs, public standpipes, water piped into dwelling/yard, boreholes, protected wells (Figure 2.7). In CoK, 63% of the households live within 200m of an improved

**Figure 2.7: Percentage of households in Rwanda with improved drinking water source**




*Source: EICV5_Thematic Report Utilities and Amenities 2018*

**Figure 2.8: Type of drinking water sources**




*Source: Fourth Population and Housing Census, Rwanda, 2012; Main indicators report*

drinking water source. While the majority of the households in Southern Province and Eastern Province still live more than 500m away from an improved drinking water source.

The pie charts show the percentage of households supplied by different drinking water sources (a) across Rwanda; (b) urban areas of Rwanda and (c) in Kigali (see Figure 2.8). The charts display that majority of the households are dependent on public standpipes for improved water supply followed by piped into dwelling/yard, which in total covers more than 70% of households in all the three cases. While the households dependent on unimproved/other drinking water source are 12.6%, 4.2% and 4.1%, respectively.

However, these water services are provided usually with frequency of two-three times a week i.e. 36–72 hours per week. The regulation developed by RURA also mentions that WASAC has to provide households with water services at least three times a week i.e. 72 hours per week.

According to the National Water Supply Policy 2016, 'Percent of people with access to an improved source of drinking water within 500 m in rural areas and 200 m in urban areas. This access should be reliable and affordable, and provide an adequate quantity (minimum 20 litres/person/day in rural and 80 litres/person/day in urban areas) within a reasonable amount of time.'

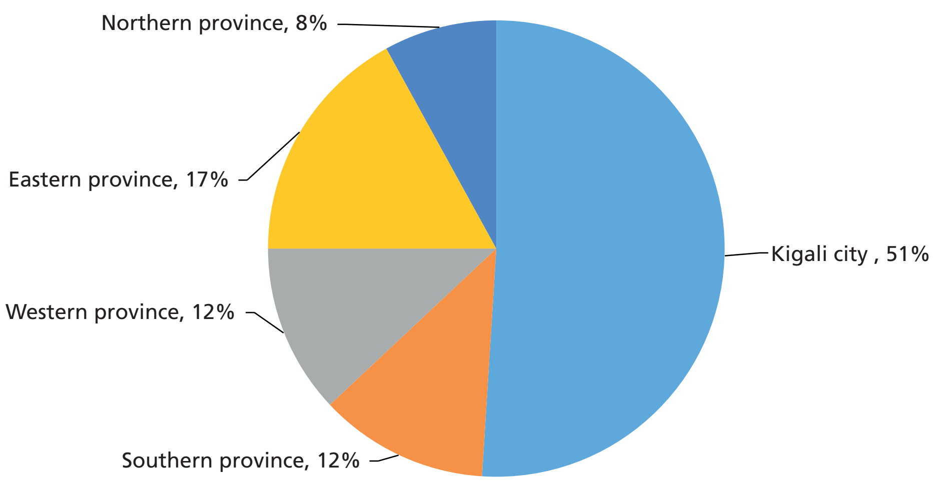
It is observed that the water availability is not at par with demand, it is less both in urban and rural areas. For instance, as per the available figures WASAC indicate that at least 120,000m$^3$ of water are needed everyday to supply the growing population in the CoK. The current capacity is around 90,000 m$^3$. In an ideal world, every city dweller should consume 100 litres per day, but Kigali residents are still relying on 40 litres, when available.[34] Furthermore, at times few areas located at the periphery of the urban areas, don't receive the minimum of water supplied. Thus, they are dependent on alternatives sources like tankers, jerrican, etc or even in worse situations have to travel some distance to fetch water. In order to avoid inconvenience to customer at times of water rationing, WASAC ensures to inform its users by putting up time table (mentioning areas which will not receive water) in the WASAC branches or communicate through local radio and newspapers.[35]

In urban areas the cost of water supply for different components like pumping, electricity, treatment etc comes under one service provider i.e. WASAC, having a cross subsidy among various components due to which the tariff in urban areas does not vary depending on the type of water supply system. Thus in urban areas, consumer pays' the actual cost which covers the investment, O&M as well as depreciation cost. It is a 100% cost recovery. However, the highest of cost in water supply is of electricity due to the topography, as the country is hilly, pumping to high altitudes require more energy. Otherwise, the cost inside the plant, is not high because the pumps are small and they don't consume high electricity.[36]

As of September 2018, the total number of water subscribers for urban areas of Rwanda is 211,479. The 51.2% of the total connections are in the CoK while 48.8% of them are distributed in the provinces (see Figure 2.9). This difference is mainly attributed to the fact that, some people in the provinces consume water supplied by Rural Water Service Providers.[37]

The water tariff in Rwanda depends on user demand. The tariff system adopted in Rwanda is based on bloc system, which means that the tariff increases by bloc of quantity of water used (see Table 2.4).

**Figure 2.9: Percentage of water subscribers across provinces and CoK**




*Source: Water and sanitation statistics as of September of the year 2018, RURA*

**Table 2.4: Water tariff**

| Customer caterogy | Block of consumption per month | Applied tariff in FRW (VAT exclusive) |
|---|---|---|
| Public tap | Flat rate per $m^3$ | 323 |
| Residential | 0-5 $m^3$ | 340 |
| | 6-20 $m^3$ | 720 |
| | 21-50 $m^3$ | 845 |
| | Above 50 $m^3$ | 877 |
| Non-residential | 0-50 $m^3$ | 877 |
| | Above 50 $m^3$ | 895 |
| Industries | Flat rate per $m^3$ | 736 |

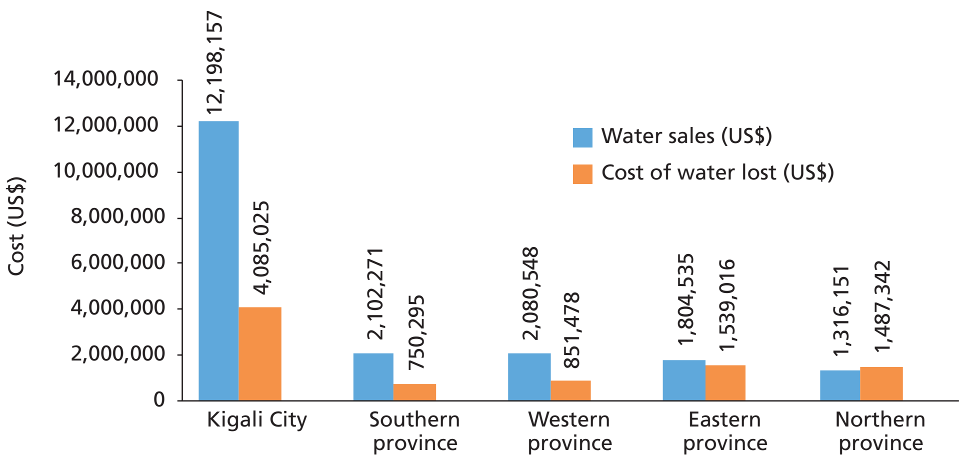
*Source: Board Decision No 002/BD/ICA-CLIA/RURA/2015*

**Table 2.5: Water per jerrican in urban areas of Rwanda**

| Water system | Water tariff per jerrycan (RWF) |
|---|---|
| Water systems using gravity | 8 |
| Electricity pumped water | 20 |
| Water systems using turbo pumped water | 19 |
| Water channelled through complex system | 16 |
| Diesel pumped water | 25 |

*Source: https://ktpress.rw/2016/12/price-of-water-electricity-reviewed-downward/*

**Figure 2.10: Water sales and losses for the provinces of Rwanda, July 2013 to June 2014**




*Reference: Karamage et al., 2016 The need for awareness of drinking water loss reduction for sustainable water resource management in Rwanda*

In order to create uniformity, the water tariff for tankers, public stand taps and water kiosks also come under the responsibility of WASAC, thus water tariff from the said sources is also set by WASAC. The water price increases with the type of water system or channel by which the clean water reaches the clients. The cost of one jerrican of 20 L capacity will be less if electricity, diesel is not used in the process  (See Table 2.5).

However, out of total water supplied, around 39 per cent of NRW loses are estimated in Rwanda. The NRW losses is primarily through leakages due to aged facilities of meters and pipeline network, water theft and errors in meter reading or billing. On account of these causes, water losses could occur at different components, such as transmission, distribution and service connection pipes, joints, valves, fire hydrants, storage tanks and reservoirs.[38] From July 2013 to June 2014, the costs of water losses as per 41% of NRW was around US$ 4,085,025 in CoK, US$ 1,487,342 in Northern Province, US$ 750,295 in Southern Province, US$ 1,539,016 in Eastern Province and US$ 851, 478 in Western Province (Figure 2.10).

As of September 2018, the water supplied to the CoK was 7,703,887 ($m^3$) out of which 4,941,486 ($m^3$) was billed and NRW loss estimated was 35.9%.[39] In a bid to promote the efficient use of water by reducing losses, WASAC is currently raising awareness among the population about non-revenue water and ensuring a metered connection. WASAC has formulated strategies to reduce NRW from 39% up to 25% within the next 10 years

**Water supply issues in urban Rwanda**

- Water availability is not at par with demand, it is less both in urban and rural areas
- Minimal information is available for groundwater resource
- High electricity cost to maintain the infrastructure
- Due to hilly terrain, high pumping cost in distribution of water supply
- Households located at the periphery of the city are still dependent on tankers, jerricans, water kiosks, etc.
- Low frequency of water supply in urban areas of Rwanda (2-3 times a week)
- High NRW loss under water supply (around 40%)

## 2.4 Storm water management in urban Rwanda

The storm water management system in urban areas of Rwanda constitute majorly drainage channels to divert runoff from the urban areas to streams and rivers.

However there are laws, policies, bylaws related to stormwater management in Rwanda. Article 28 of the Law governing roads in Rwanda talks about water drainage system activities related to water drainage system. Apart from this the latest 'Sanitation Policy and Sanitation implementation strategies' includes 'storm water management' as one of the objectives for the policy vision. The document presents the sector's approach on how to achieve the Vision 2020 and EDPRS objectives and breaks them down into concrete principles, objectives and statements.

Following are the targets and indicators given for stormwater management in urban Rwanda:

| Storm water management | Baseline 2015 | Target | | | | |
|---|---|---|---|---|---|---|
| | | 16/17 | 17/18 | 18/19 | 19/20 | 29/30 |
| Percent of urban population in areas covered by master plans with storm water considerations | N/A | 20 | 40 | 60 | 80 | 100 |

The policy also states that 'Storm water shall be understood as a resource. Diversion of storm water has a series of advantages, including financial, over traditional approaches to storm water management, which usually gave priority to costly network constructions. 'Water sensitive urban design' or 'Low Impact Development' are approaches to urban planning and design that integrate management of the total water cycle into urban development.'

Article 16 of Rwanda building code mentions the minimum building performance requirements for rain and surface water harvesting and acknowledges rainwater harvesting to be considered as a complementary water supply to other regular sources. It also mentions about 'Storm-Water and Erosion Control Planning and Management'; however, no details are given for swales, basins and ponds if sites are large in area.

Over the time, it has been realised that there is a need to consider storm water as a resource. It should be attenuated and retained at source allowing it to infiltrate into aquifers and flow gradually into receiving water bodies. Storm water infrastructure should be designed to enhance the urban landscape and provide recreational opportunities.[40]

However, according to the water resources management sub-sector strategic plan in Rwanda, the water sector for a long time focused on infrastructure development for water supply, hydropower production and agriculture. Consequently, little resources were allocated to storm water management. The 2011 national policy for water resources exposed the gaps which the Government of Rwanda is now addressing. The CoKs stormwater management is governed under a complex institutional framework, as shown in the table below. The institutions can be categorized into policy and oversight institutions, regulatory institutions and implementing agencies.

| **Policy and oversight institutions** | **Regulatory agencies** | **Planning, designing, Implementing and O&M** |
|---|---|---|
| Ministry of Environment (MoE), Ministry of Agriculture and Animal Resources (MINAGRI);<br>Ministry of Infrastructure (MININFRA), Ministry of Trade and Industry (MINICOM), Institute of Policy Analysis and Research (IPAR);<br>Ministry of Disaster Management and Refugee Affairs (MIDIMAR); Districts | REMA, RSB, RURA | Local Governments, District and lower structures |

### Stormwater management in CoK

In CoK again, stormwater management mainly constitute the drainage network containing a few complex inter-connected networks of small drains. The existing drains are usually constructed on one side of the road and the ones in the City centre are mostly covered. In general, the existing drainage network in the City consists of 3 types of drain structure: Open masonry storm channels; covered masonry storm channels and unlined natural channels.[41] The runoff impact of unmanaged storm water on people and environment is a challenge facing the CoK. Poorly maintained infrastructure causes erosion of usable land, increases flooding, and endangers private and public infrastructure including human life.[42]

Some of the key issues to be addressed are as follows:

- Common drainage channels for storm water and waste water flow, it is affecting the water quality in the public drains and eventually the receiving water bodies.
- Maintenance and upgrading of the damaged channels, damaged channels do not function at their optimum design capacity, which cause localised flooding in the event of heavy rain
- No provision of stormwater harvesting or SUDS to infiltrate runoff. Storm water is presently seen as a liability than a resource to be valued.
- No guidelines/standards for stormwater management. Without a standard local design guideline, there is no common basis for designing drains in the new developments or for verifying the adequacy of the drainage capacities of the receiving drains and canals.
- Erosion at the areas with steep slopes. Gikondo industrial area and Nyamirambo area on the eastern slopes of Mount Kigali are some of the examples of such problematic areas. The eroded soil eventually end up in the water courses and water bodies, thus reducing the drainage capacity and polluting the water environment.

**Figure 2.11: Flash floods in CoK**

### Periodical occurrence of flooding in Kigali

Rapid urbanization in the CoK, combined with extreme weather, poor drainage system and less infiltration contributes to high runoff and frequent urban floods.

Although flooding has been experienced since 1960s in CoK, its frequency has significantly increased since 2000s, and its impacts have been great on human development, properties, infrastructures as well as environment. Currently, some areas of Kigali are facing destructive flooding thus putting at risk the major infrastructures in the vicinity.

A series of flash floods always occur in every heavy rainfall season in Kigali mainly affecting various areas including Nyabugogo, Kinamba, Gacuriro, Magerwa, Rugunga, Rwandex and Mulindi, originating in a strongly urbanized area causing damages along the channels, roads, bridges, culverts, properties as well as humans. As a consequence, extremely high runoff is generated in the sub-catchment causing repeated inundations in the above mentioned areas.

One of the factors that contribute to flooding in Kigali is the amount of ground that is available to absorb water. When development occurs, hard surfaces such as rooftops, pavement and driveways do not allow water to be absorbed into the ground and more of the rainwater becomes runoff flowing directly into streams and drainage ways. As a result, the 'peak flow' in a stream or drainage way after a storm event will be higher and occur faster. Without water sensitive planning, major land use changes have affected the impervious area of a site and result in a significant increase in flooding in many parts of the city (see Figure 2.11).

# 3 Mitigating risk in Water Management

In order to keep pace with the increasing rate of urbanization and exploitation of water resources, it is important to come up with strategies that are localized and affordable. This section will give details of the concept and methodology to mitigate water management at various scales.

RWH involves the capture, storage and use of rainwater and runoff for domestic or agricultural purposes. Essentially, RWH systems use the principle of conserving rainwater 'where it falls', in the process recharging groundwater.[43] In urban area of Rwanda, directing more and more rain only into surface water drainage systems is not the solution, it will eventually overload them, causing water logged areas with unhygienic conditions. In existing spatial planning of CoK, the focus on lakes, floodplains, buffer or green areas for surrounding vulnerable and watershed areas is neglected.

The need of the hour is to recognize the importance of urban green spaces in creating a naturally-oriented water cycle while contributing to the beauty of the city. This can be achieved by planning urban development through the following water sensitive approach so as to lower the hydrological impact of urbanization by using current opportunities in order to increase the carrying capacity of the area in terms of improved water management.

- Promoting rainfall infiltration into the soil at public places, including open areas in cities through elements of landscape design of vegetated swales and bio-retention systems. (Swales are linear vegetated channels with a flat base that encourage sheet flow of water through grass or other robust vegetation. Bio-retention areas and rain gardens are planted areas designed to provide a drainage function as well as contribute to the soft landscape).
- Protecting local water bodies (lakes, ponds and wetlands) which act as sponge in high rainfall events hence reducing the volume of rainwater runoff and lowers the risk of flood and water logging.

## 3.1 City/zonal scale

Stormwater harvesting management can conserve storm water resource while offering numerous benefits by improving the urban environment, reducing the danger of flooding, increasing opportunities for recreation and leisure activities, and reducing flooding damage and cost of drainage systems.

Public open spaces in a city provide the opportunity to combine the function of public open space with habitat retention (trees and watercourses), pollution abatement and storm-water management.

**Wetlands/lakes:** In densely populated urban areas, waterbodies and lakes can be planned with a green buffer area that can act as a treatment zone. Waterbodies play a major role in the natural hydrological cycle and offer healthy recreational spaces.

**Recreational areas:** Where open spaces are located in consideration with the natural stream system, they can be also used to prevent and mitigate floods by retaining and detaining storm water and to purify and infiltrate runoff, thus recharging groundwater with clean water.

**Roads and streets:** Roads and streets constitute up to 70 per cent of the impervious urban area and serve primarily to transport people and goods. But they also act as important conveyors of storm water; in fact, they constitute the major drainage system that serves as an important flow path when the drainage pipes underneath are charged beyond their capacity.

**Inclusion of storm-water streams in urban fabric:** Storm-water streams/ watercourses represent natural drainage lines and therefore need to be considered part of the storm-water management strategy for a development site. The concept of storm-water streams in urban fabric recognizes that there are benefits in considering maintenance of water quality, habitat retention and restoration, water conservation and a wider choice of recreational opportunities in an integrated fashion.

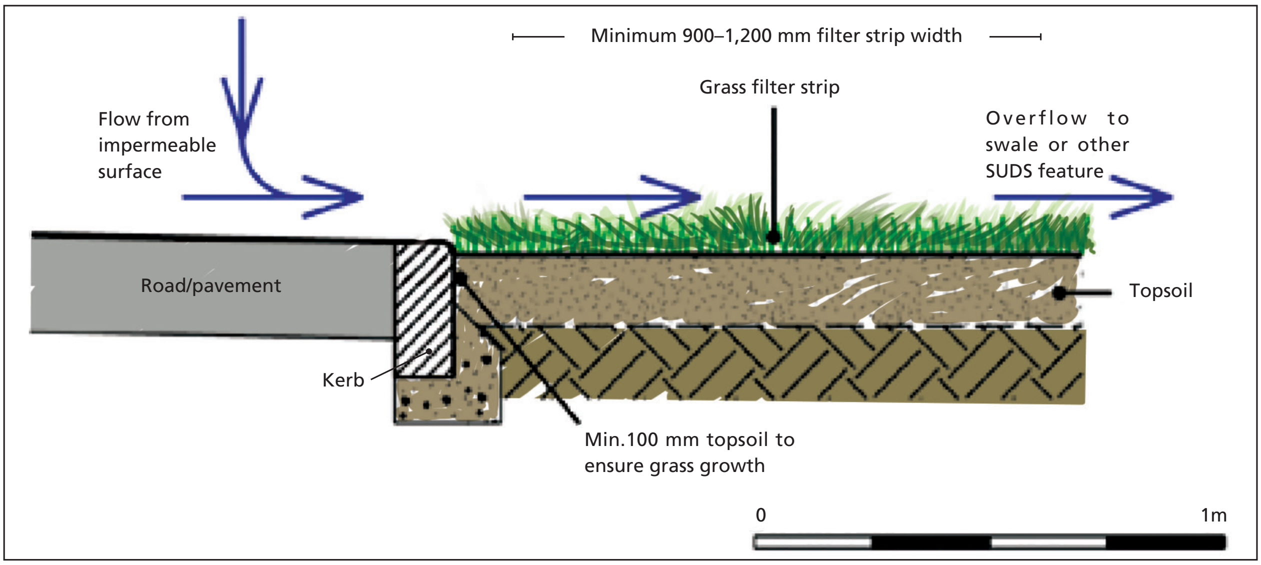
### 3.1.1 Sustainable urban drainage systems

The conventional approach to drain the runoff from built-up areas is through underground drainage systems that convey water from built-up areas. This conventional urban drainage system focuses on quantity as it aims to remove excess water from urban areas as quickly as possible to avoid possible flooding incidents. Deliberate stormwater management by providing more space and time to moderate increased runoff can also contribute to recharging groundwater and creating assorted surface storages. This broad approach of rainwater harvesting, referred to as Sustainable Urban Drainage Systems (SUDS), can considerably contribute to local water-resource augmentation in Kigali.

These measures can be undertaken in public open spaces, generally located outside the envelope of individual developments. Public open space measures are characterized by their location within green spaces or other clearly defined public areas that can manage the storage and conveyance of surface water runoff. Depending on the design and characteristics of the site, a convenient location where the intermediate source control area becomes part of accessible public open space.

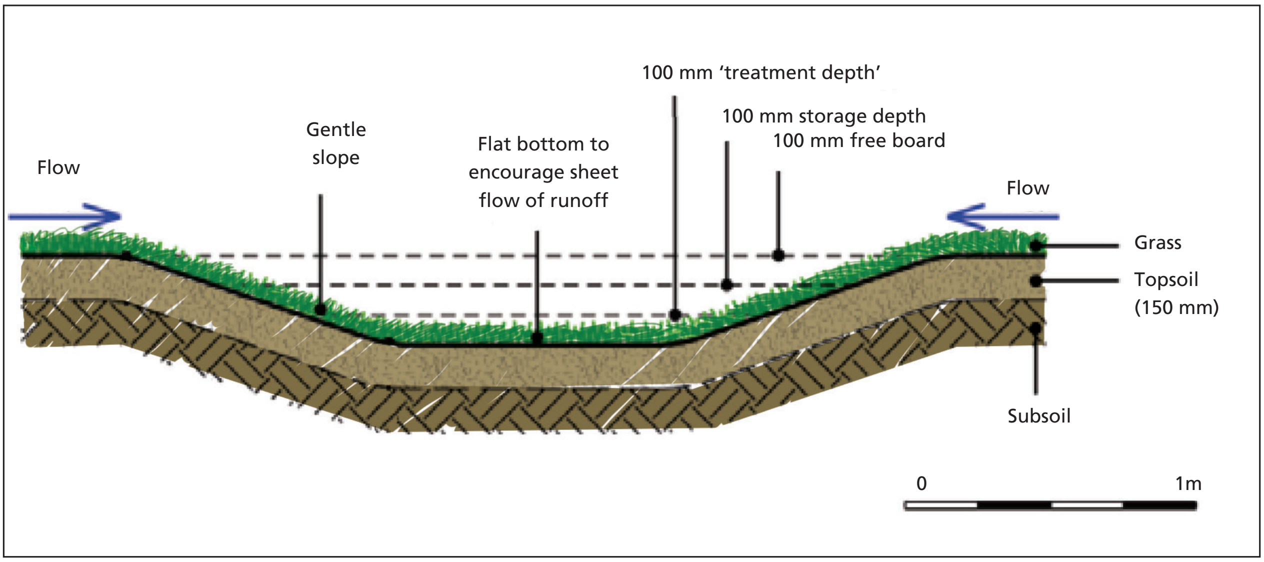
The following are the SUDS measures for public open spaces:

Filter strips: Filter strips are grass or other densely vegetated strips of land that collect surface water runoff as sheet flow from impermeable surfaces.



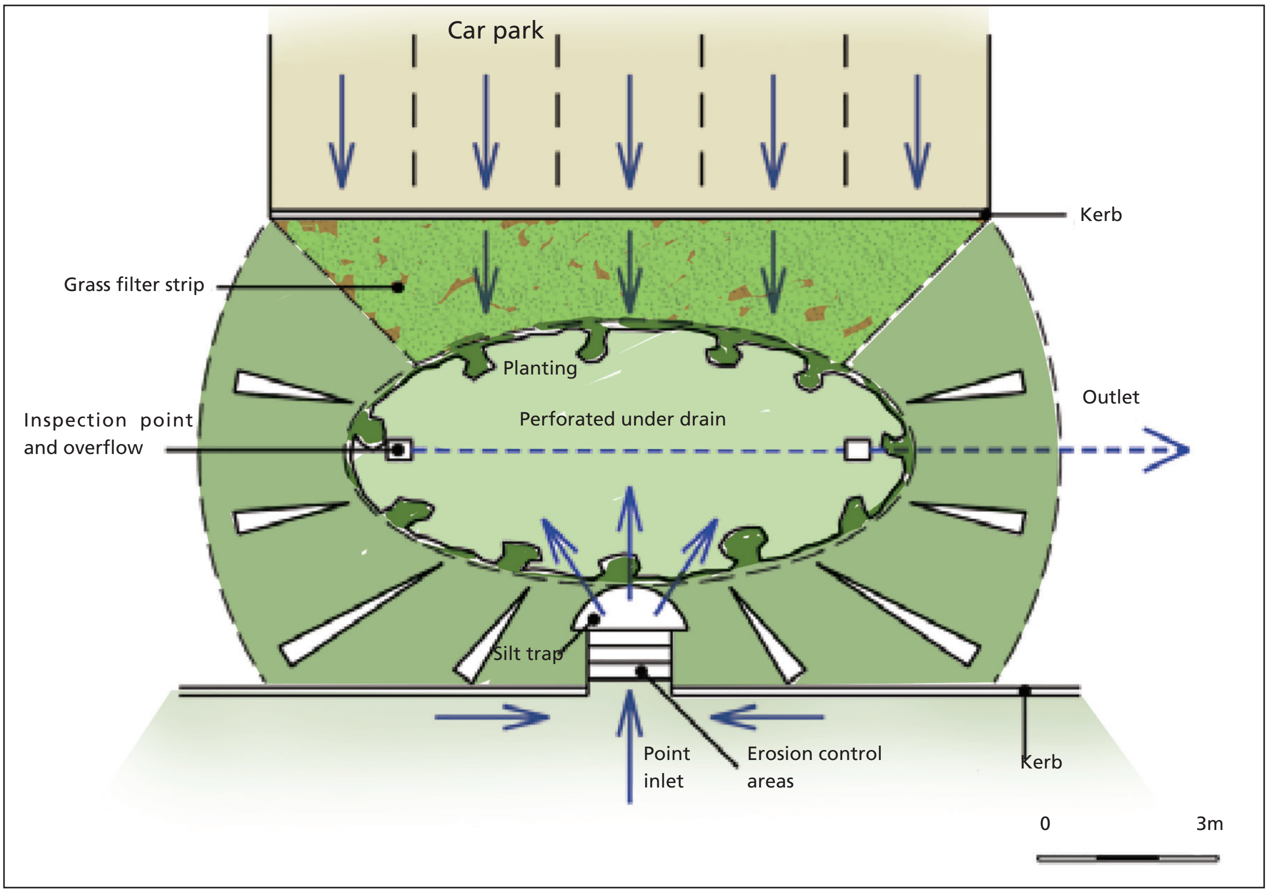

*Source: CSE, 2016*

**Swales:** Swales are linear vegetated channels with a flat base that encourage sheet flow of water through grass or other robust vegetation. They collect, convey and sometimes store surface water runoff allowing water to soak into the ground where soil conditions are suitable.



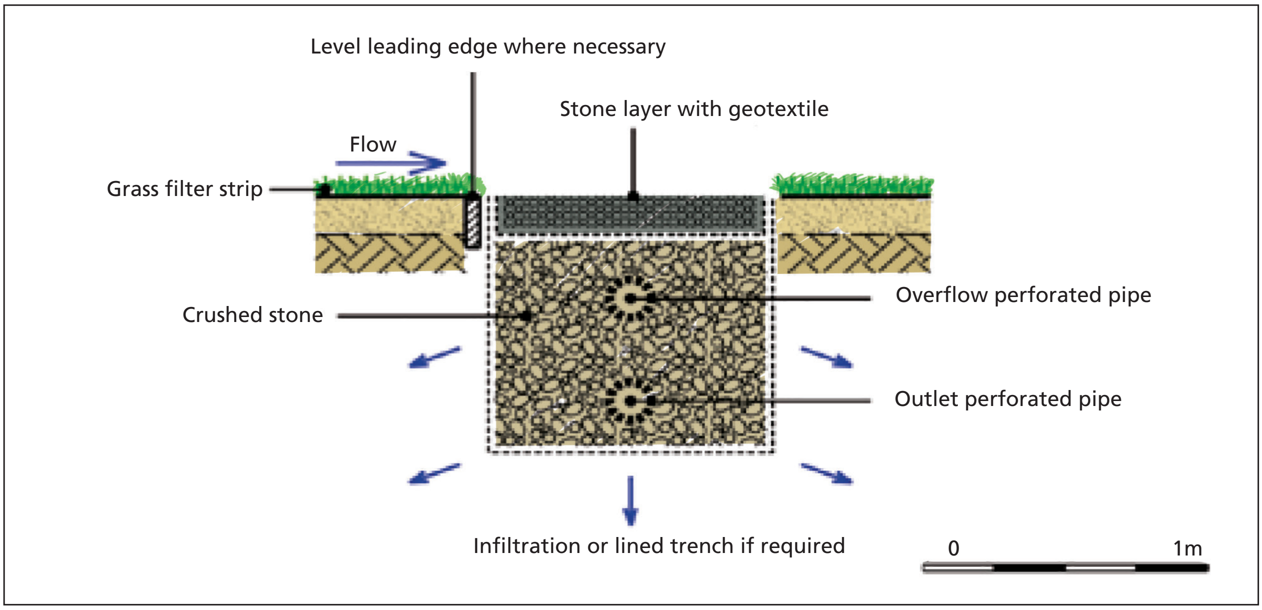

*Source: CSE, 2016*

**Bio-retention areas and rain gardens:** Bio-retention areas and rain gardens are planted areas designed to provide a drainage function as well as contribute to the soft landscape.



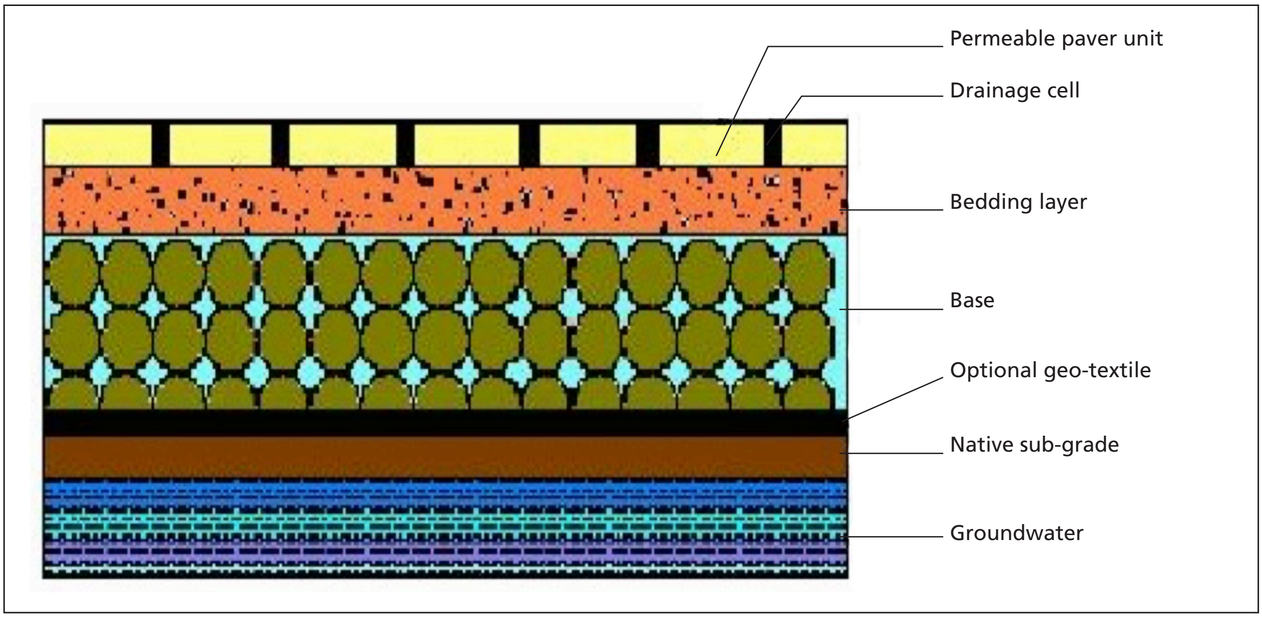

*Source: CSE, 2016*

**Filter drains and trenches:** Filter drains and trenches are linear excavations filled with stone that ideally collect surface water runoff laterally as sheet flow from impermeable surfaces. They filter surface water runoff as it passes through the stone allowing water to infiltrate into soil or flow.



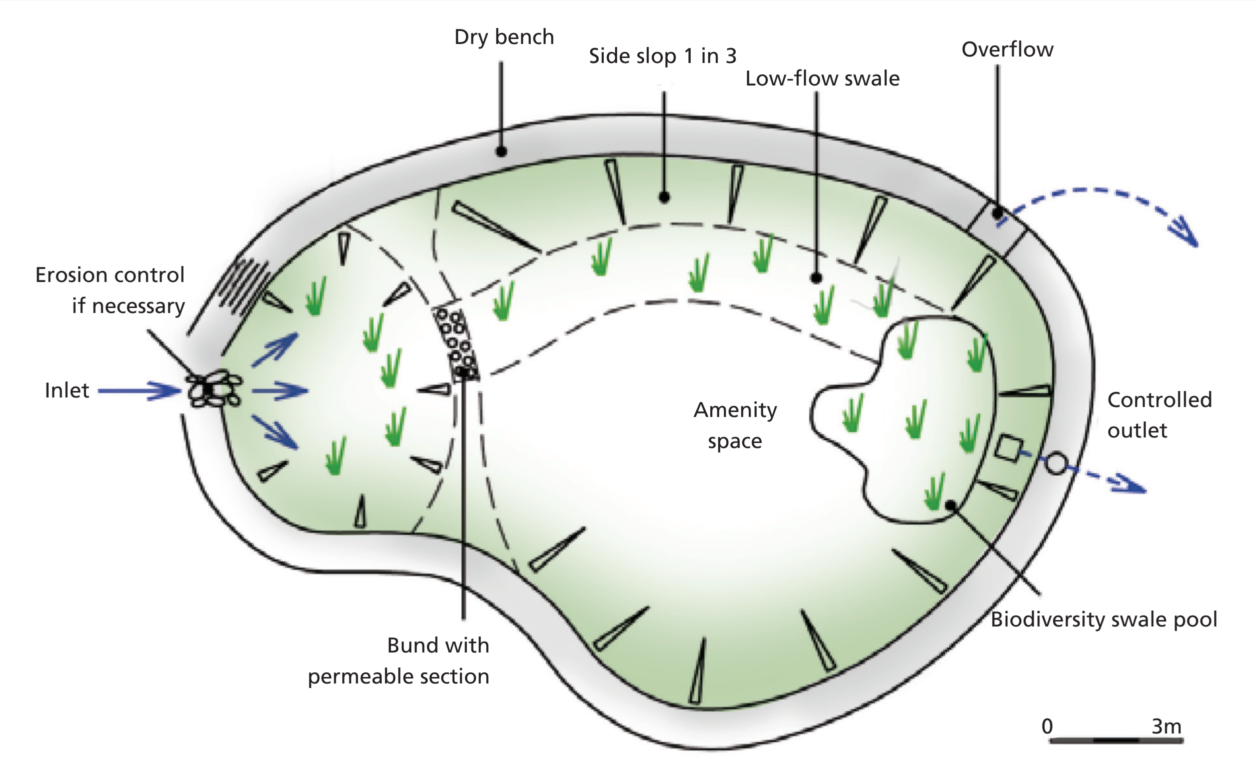

*Source: CSE, 2016*

**Permeable pavements:** Permeable pavements provide a surface that is suitable for pedestrian or vehicle traffic while allowing surface water runoff to percolate directly through the surface into underlying open stone construction.



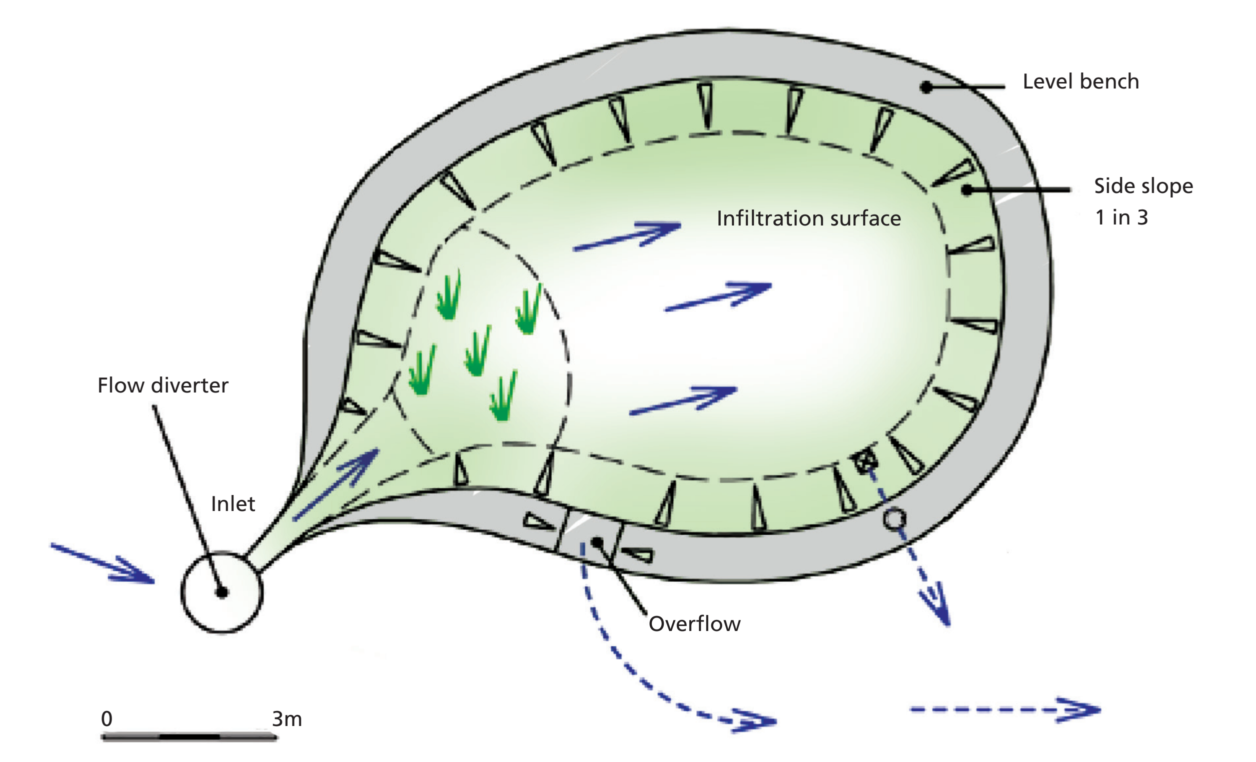

*Source: CSE, 2016*

**Detention basins:** Detention basins are vegetated depressions in the ground designed to store surface-water runoff and either allow it to soak into the ground or flow out at a controlled rate. Within development, these basins are usually small grassed areas, sometimes with a micro-pool or planted area at a low point where some standing water can accumulate.



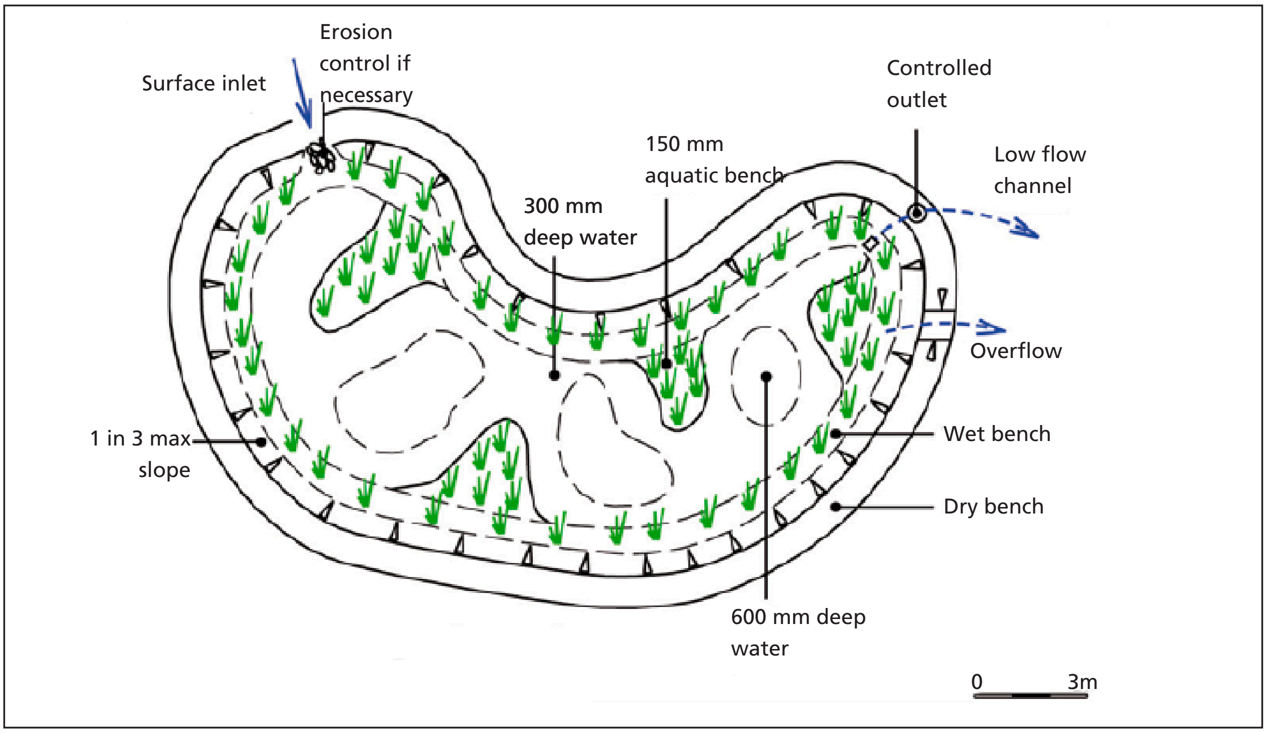

*Source: CSE, 2016*

**Infiltration basins:** The basins collect surface-water runoff from small areas and are usually off-line to prevent siltation.



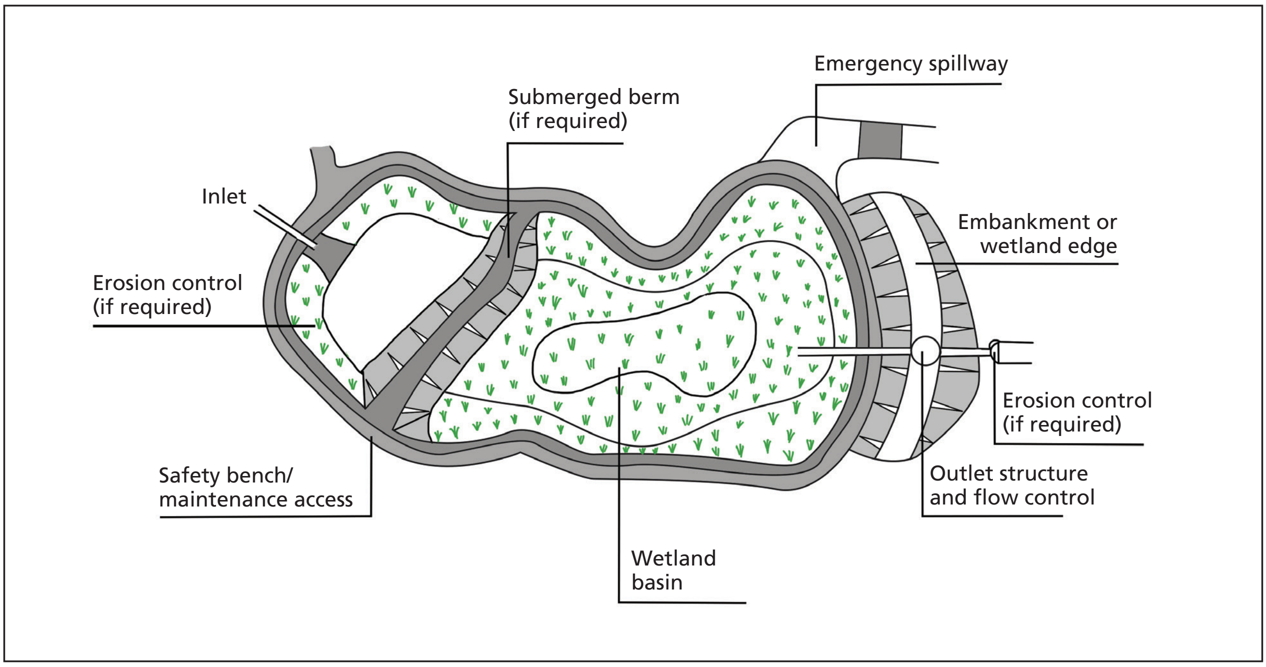

*Source: CSE, 2016*

**Ponds:** Ponds are depressions in the ground that contain a permanent or semi-permanent volume of water.




*Source: CSE, 2016*

**Wetlands:** Wetlands are shallow ponds with marshy areas, covered in aquatic vegetation. They retain sediments for an extended time and remove contaminants by facilitating adhesion to aquatic vegetation and aerobic decomposition.

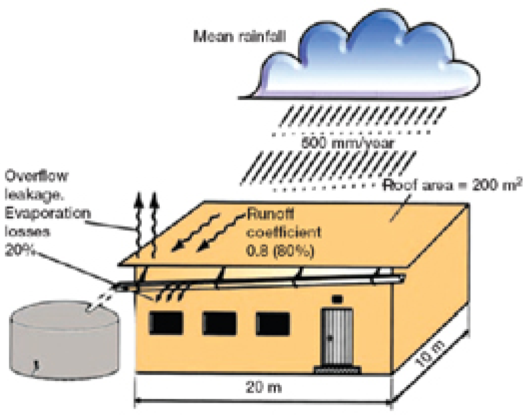



*Source: Rohilla et al. 2017, Mainstreaming rainwater harvesting in Noida, Centre for Science and Environment, New Delhi*

### 3.2 At individual scale

In urban areas, rainwater can be collected from the roof, paved and unpaved areas of a house, a block of flats, a colony, parks, playground, parking areas, schools, office complexes lakes and tanks.

There are two ways of using the harvested rainwater:
1) through storage in receptacles and
(2) to recharge the aquifer




**Runoff = A x R x C**
A = Area
R = Rainfall in metres
C = Runoff coefficient

**An example**
A = 100 $m^2$
R = 1400 millimeters
C = 0.85

**Runoff = 1,19,000 litres**

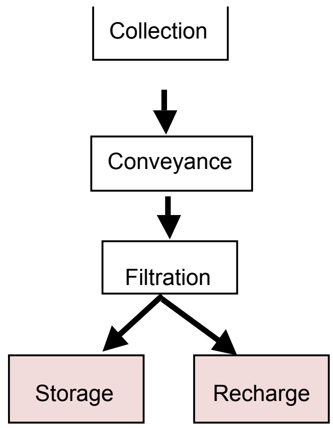
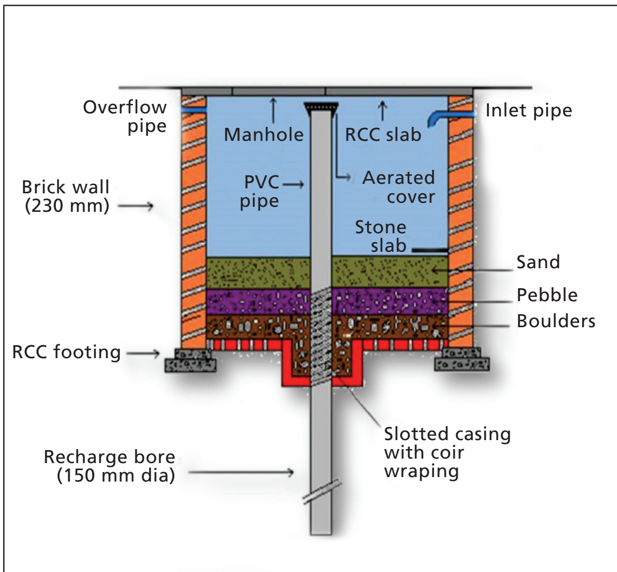


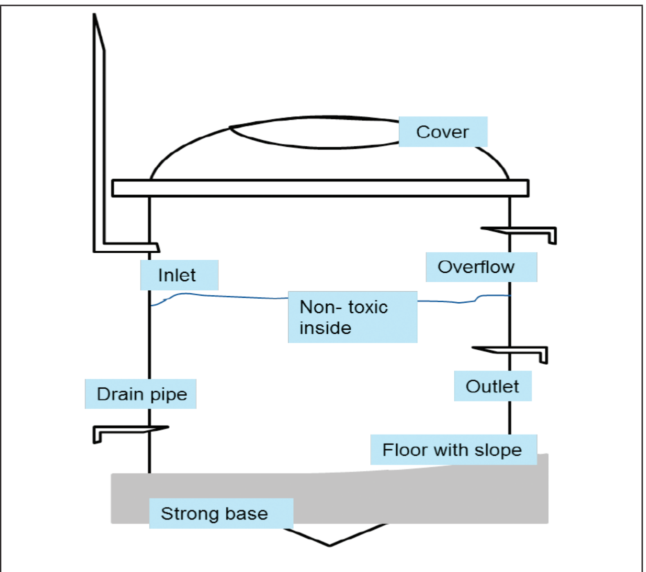

**Table 3.1: Rainwater harvesting techniques**

| Recharge structures | Storage tanks |
|---|---|
| • Recharge pits<br>• Recharge pits with bore<br>• Recharge well<br>• Recharge trenches<br>• Recharging through abandoned bore wells or tube wells<br>• Recharging: using bore wells and dug wells | • Polyethylene<br>• Polypropylene and similar synthetic material (PVC tanks)<br>• Brick masonry<br>• Reinforced cement concrete (RCC tank)<br>• Ferro-cement<br>• Galvanized iron (GI tanks) |

*Source: CSE, 2016*




**Typical cross section of recharge structure**

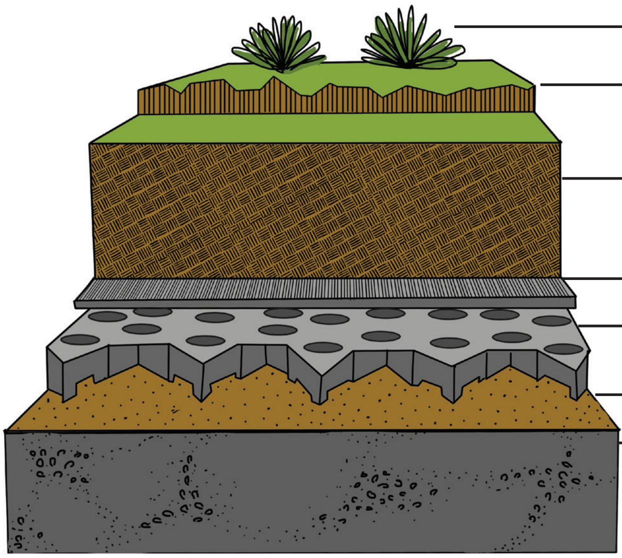



**Typical storage structure**

*Source: Kavarana, G. Sengupta, S. (2013). Catch water where it falls. New Delhi: CSE.*

### Other on-site landscape features

**Green roofs:** Green roofs are multi-layered systems comprising vegetation cover or landscaping above structural slab of open terrace/roof. Their aim is to intercept and retain precipitation which then results in fewer surfaces run-off.




*Source: Rohilla et al. 2017, Mainstreaming rainwater harvesting in Noida, New Delhi*

## 3.3 Rooftop RWH

In urban areas, rooftop rainwater can be conserved and used for recharge of groundwater. This approach requires connecting the outlet of storm water drains and pipes from rooftops to divert the water to existing wells, tube wells, bore wells or specially designed recharge wells. The urban housing complexes or institutional buildings in CoK having large roof area and can be utilized for harvesting rooftop rainwater. Rooftop RWH can also be adopted to meet domestic water requirements. The rooftop rainwater can be stored in specifically constructed surface or sub-surface tanks. Dependence on groundwater has increased manyfold and the natural recharge to groundwater has decreased due to urbanization, construction of buildings and paved area. In the built-up area of Kigali rainfall from rooftops can be collected and diverted to the open wells, tubewells and borewells through the medium of filters.[44]

Rooftop RWH, which involves the collection of rainwater from the roof of the buildings and its storage in surface tanks or recharge to sub-surface aquifers, plays an important role in the conservation of water. The run-off from rooftops can be effectively used for artificial recharge of groundwater replenish the fast depleting aquifers.

# 4 Case studies

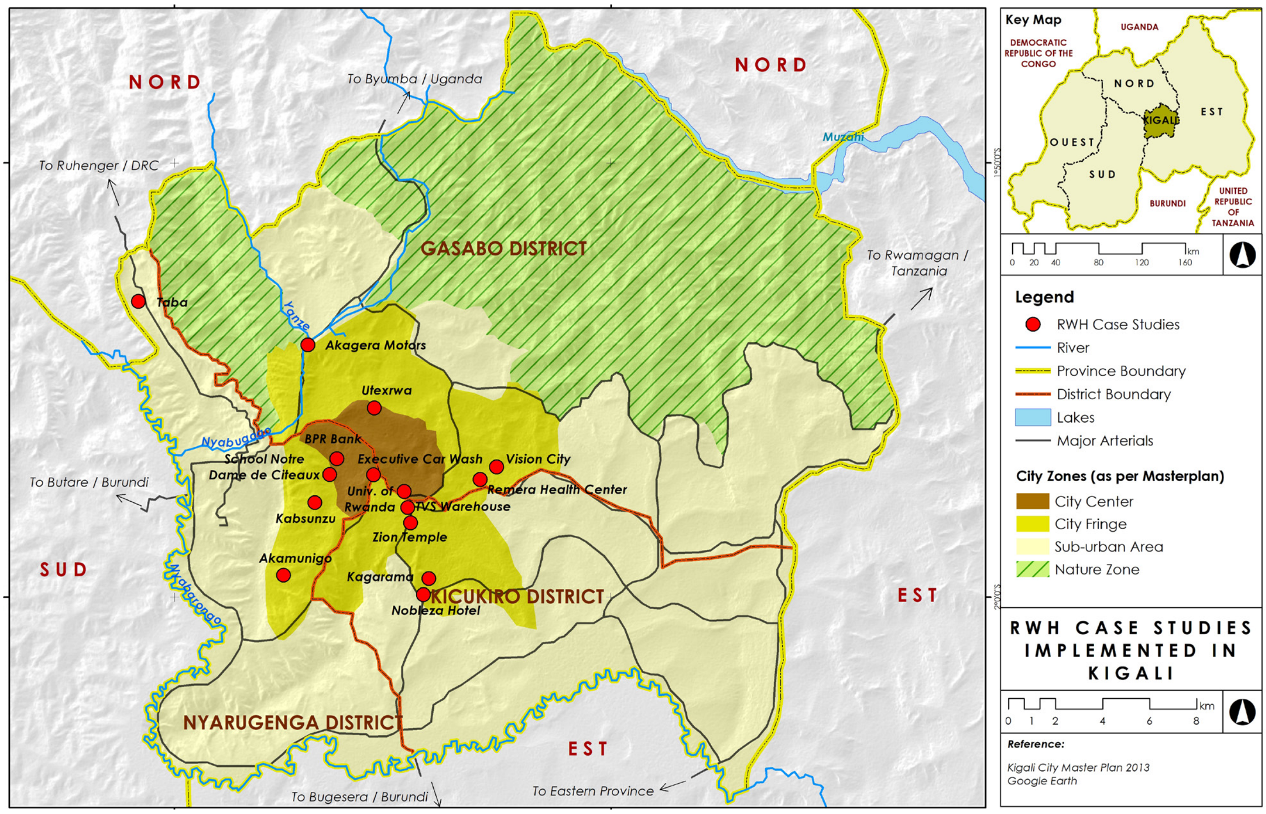
This chapter documents the implemented projects on RWH in Kigali, keeping in view social, economic and environmental benefits. A list of over 20 potential sites were shared by RWFA, CSE alumni and WaterAid Rwanda. The case studies were viewed on various parameters such as type of RWH structure (storage or recharge), socio-economic and environmental impacts and water supply scenario. This enabled gathering of in-depth information on RWH structures at the site which included details on design specifications, operation and maintenance, performance monitoring and socio-economic evaluation. After collecting the data, making site visits and doing KII and FGD with potential stakeholders, 15 case studies were finalised for documentation against set of criteria. The analysis of data collected and information shared during interviews of the stakeholders have been used to validate the status of the case studies. The selected case studies mentioned in Table 4.1 and Map 4.1 have been discussed in the following section.

**Table 4.1: Identified case studies in Kigali**

| School | Public-Semi public | Small scale industry and hotel | Neighbourhood / housing |
|---|---|---|---|
| Lycée Notre Dame de Cîteaux | University of Rwanda, CMHS-Remera Campus | Akagera Motor | Vision City Phase I |
| GS Kabusunzu | BPR | UTEXRWA SA | Taba Grouped Settlement |
| GS Kagarama | Remera Health Centre | PT Executive Car Wash | |
| GS Akumunigo | Zion Temple Celebration Centre | TVS Warehouse | |
| | | Hotel Nobleza | |

*Source: CSE, 2018*

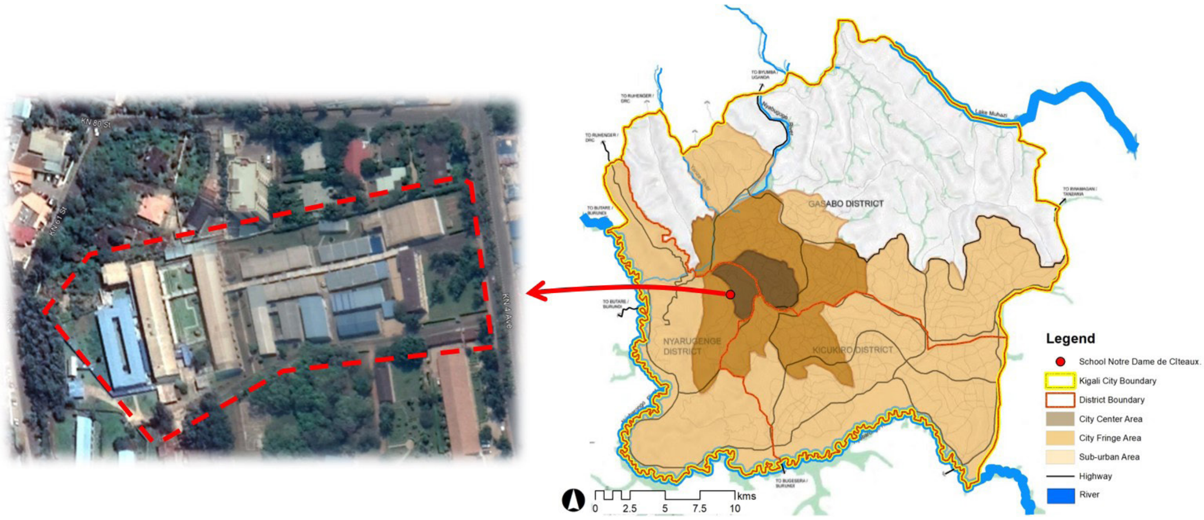
**Map 4.1: Location of RWH case studies in Kigali**



## 4.1 RWH system in schools

### 4.1.1 Lycée Notre Dame de Cîteaux Secondary School

**Location of Lycée Notre Dame de Cîteaux school in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of implementation of RWH systems in Lycée Notre Damme de Cîteaux secondary school is to reduce dependence on the municipal water supply and to create the sustainable water resource management within the campus.

**Lycée Notre Dame de Cîteaux secondary school**


*Source: CSE, 2018*

"Objective of implementing RWH system was to reduce the water supply from municipal source thus reducing the cost of water supply and also to keep the environment safe. As municipal water is not regulated, we don't have to worry as RWH is the alternative source used. Apart from cleaning floor of the school, rainwater is used for construction purpose"
*Headmistress, Helen Nayituriki*

| Salient features | | | |
|---|---|---|---|
| Location | Nyakabanda sector, Nyarugenge district | Implementing organization | Lycée Notre Damme de Cîteaux school |
| Landuse | School, Institutional | Total volume of rainwater harvested annually ($m^3$) | 3939.07 |
| Total site area | 2.56 Hectares | Harvested water is used for | All purposes (except cooking and drinking) |
| Catchment area ($m^2$) | 4634.2 | Operational since (year) | 1997 |

**Background**

Kigali has two major girls' schools namely Lycée Notre Damme de Cîteaux and FAWE. Lycée Notre Damme de Cîteaux is a secondary boarding school for girls run by catholic sisters and has been one of the main performers in national examinations. The school is located in Indangamirwa village, Kiyovu cell, Nyarugenge sector, Nyarugenge district of Kigali Province in Rwanda. It was built in 1967 and is spread across 2.5 hectares of land. It lies in the heart of CoK.

**Rooftop area used as catchment for collection of rainwater**

*Source: CSE, 2018*

**Water scenario**

The school is dependent on municipal water supply (WASAC) and harvested rainwater. It caters to around 800 students and nearly 70 staff across the premises. However, water from WASAC is not regulated. During the dry season, the municipal water supply is low (at 50% to the total water demand), which is being substituted by rainwater harvested within the school.

**Rainwater harvesting system**

The school practices RWH retrofitted in the year 1997 and has been modified further. The catchment area includes all the rooftop of different building blocks of the school.

Presently, there are 20 plastic tanks (ranging from 3-10 $m^3$) and 3 masonry tanks (2 of 60 $m^3$ and 1 of 120 $m^3$) used for storing the harvested rainwater. All the

**Tank used for storage of rainwater**

*Masonry tank used for storage constructed above ground*

*Plastic tank used for storage constructed above ground*

*Source: CSE, 2018*

tanks are placed above ground level. Since the water from paved and unpaved surface is not harvested, the runoff from them passes directly into the open drain.

Initially, between 1997 to 2000 masonry tanks were built with the high cost ranging 7–8 million Rwandan francs (RWF) per tank.

**Operation and maintenance**
The O&M for the system is being practiced occasionally. Depending upon the incidences of system clogging, the catchment area and the rain outlets are cleaned 2–3 times per year. The first flush system which avoids first one or two spells of season rainfall is installed before the plastic tanks. Further, the RWH structures do not have any other filtration system. Manual cleaning of the tanks is being done twice a year by the supporting staff.

In addition, organoleptic parameters (color, odor and taste) are used to check the quality of harvested water. The quality of water is considered good by the school, if the harvested water has no odor, no color and no peculiar taste.

**Socio-economic and environmental benefits**
The objective of implementing RWH was not only to reduce the dependence of municipal water supply but also to keep the environment safe. Over the years the municipal water supply bill has reduced, adding to the payback of the system installed. The reduced pressure on the public water supply system has a positive impact on the environment. This activity can also earn carbon-credits in terms of energy conservation for in-situ water augmentation on campus instead of sourcing water from distant sources. The increase in availability of water has also contributed in maintaining its green landscape round the year hence reducing erosion.

The RWH system implemented in the school has created wider acceptance and dissemination of the concept among the students. Also, in the school, RWH is part of the curriculum within the environmental course.

'Over the years we have been using the rainwater for a number of purposes and have not come across any health-related issue.'
*Paul, Gardener*

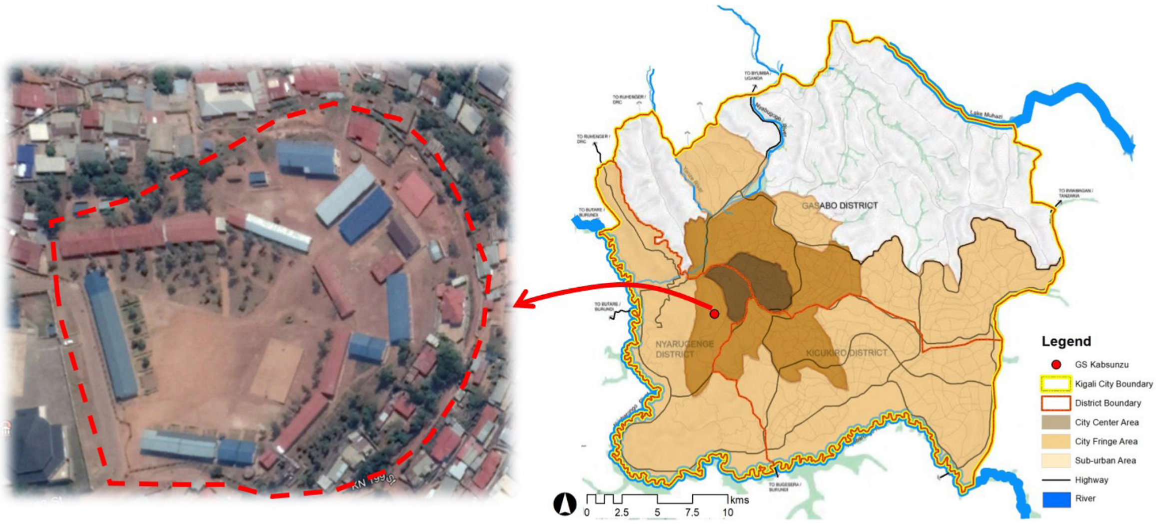
'At national level, RWH is encouraged in schools. Every school wishes to have RWH system if they have money.'
*Felicien, Engineer and Contractor*

### Greenery of the school irrigated by harvested rainwater

*Source: CSE, 2018*

### 4.1.2 GS Kabusunzu Secondary School

**Location of GS Kabusunzu school in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of implementation of RWH systems in GS Kabusunzu secondary school is to meet the growing water demand and reduce stormwater runoff from the campus.

**GS Kabusunzu secondary school**

*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Kagarama sector, Kicukiro district | Implementing organization | SNV and Right to Play |
| Landuse | School, Institutional | Total volume of rainwater harvested annually ($m^3$) | 2802.96 |
| Total site area | 4.5 Hectares | Harvested water is used for | All purposes (except cooking and drinking) |
| Catchment area ($m^2$) | 3297.6 | Operational since (year) | 2007 |

**Background**

The school is an A level secondary school located in Ntaraga village, Munanira I cell, Nyakabanda sector, Nyarugenge district of Kigali. Most parts of Nyakabanda sector are occupied by high density informal housing. Public facilities are scattered among the housing areas and are accessible by unpaved roads.[45]

**Table 4.2: Breakup of water demand/day in the school**

| Activity | Water demand (L) |
|---|---|
| Cooking | 200 |
| Cleaning | 1020 |
| Toilet | 200 |
| Drinking | 100 |

*Source: CSE survey, 2018*

**Water scenario**

The current water demand in the school is dependent on municipal supply (WASAC) and harvested rain. Per month the water supply from WASAC is 400$m^3$ at a cost of 16,000 RWF, remaining demand is met by rainwater. For a total strength of approximately 2848 students and staff (of which 1914 are in the primary wing and 934 in secondary wing) a total of 1520 L of water is required per day (See Table 4.2).

**Rainwater harvesting system**

RWH structures have been constructed in 2012. The funds for implementation of the systems came from Non-government organisations namely 'SNV' and 'Right to Play'. Rooftop RWH is being practiced in the school, the harvested water is used for all other purposes except for drinking and cooking. A total of 9 tanks have been installed for the intervention (See Table 4.3 ).

**Table 4.3: Type of storage systems in GS Kabusunzu school**

| S. No. | Type of Storage | Positioning | Capacity |
|---|---|---|---|
| 1. | Plastic tanks (5 in total) | Ground Level | 5 $m^3$ (each) |
| 2. | Ferrocement (2 in total) | Ground Level | 45 $m^3$ (each) |
| 3. | Ferrocement | Ground Level | 100 $m^3$ |
| 4. | Plastic lined tank | Under Ground Level | 500 $m^3$ |

*Source: CSE survey, 2018*

**Storage tanks used for collecting runoff from rooftop**

***Masonry tank used for storage constructed above ground***

***Plastic tank used for storage constructed above ground***

*Source: CSE, 2018*

### Operation and maintenance

The first flush system is installed before the ferrocement and plastic lined storage tanks in order to discard one to two spells of rain. The ferrocement tanks also have a sand filter to ensure additional level of filtration. The gutters are cleaned thrice a year. Till date neither the tanks nor the catchments have been cleaned.

***Conveyance system from rooftop to underground storage tank***

***Underground storage tank***

*Source: CSE, 2018*

### Socio-economic and environmental benefits

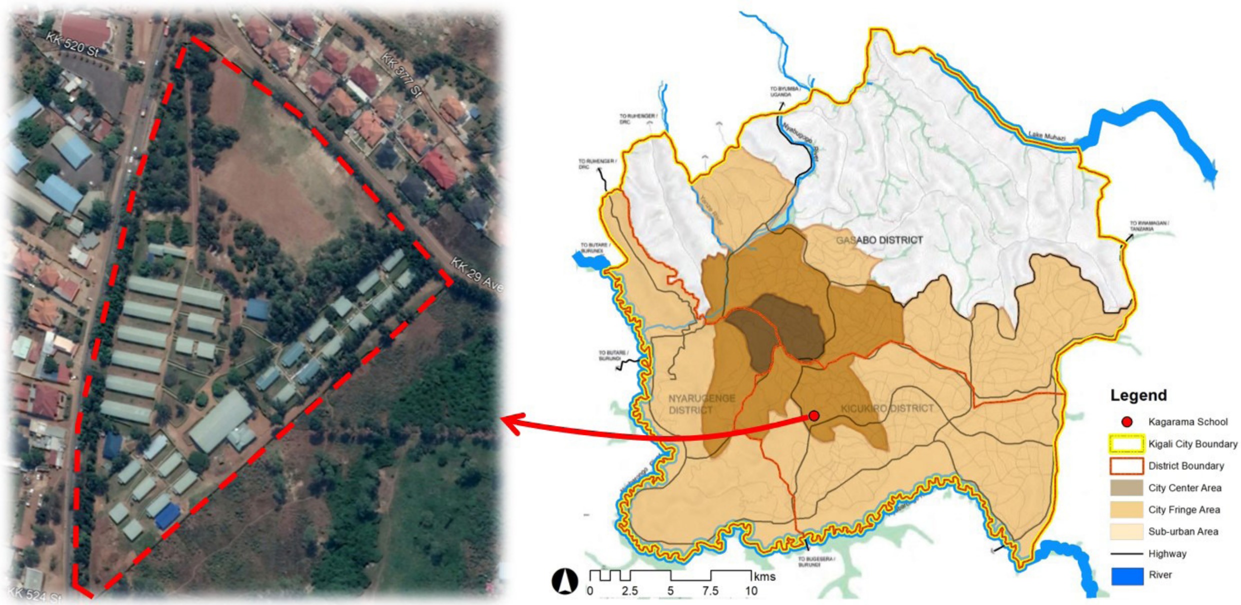
There is no report of any major issue of water shortage in the campus as rainwater is being used as an alternative source of water. At times the neighbouring residences also draw harvested rainwater from the school for their household purpose. With efficient use of the system, the municipal water supply bill has reduced thus adding to the payback of the harvested system installed. RWH has helped to provide green landscape area in the previously deserted school along with erosion control.

RWH is included as one of the subjects in the elementary science and technology course of the school. Further clubs are created for awareness generation towards protection of water and environment as a whole.

'Due to RWH system, there is no shortage of water, supporting staff don't have to fetch water from far away. Also, neighbours fetch water from school premises. Further, hygiene is increased as classrooms are cleaned.'
*Murinda Joseph Eric, Principal*

### 4.1.3 GS Kagarama Secondary School

**Location of GS Kagarama school in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The main objectives of implementation of RWH in the school is to minimize water supply from WASAC and also to reduce water scarcity by using rainwater as an alternative water source.

**GS Kagarama secondary school, Kigali**

*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Kagarama sector, Kicukiro district | Implementing organization | RWFA |
| Landuse | School, Institutional | Total volume of rainwater harvested annually ($m^3$) | 2802.96 |
| Total site area | 4.5 Hectares | Harvested water is used for | All purposes (except cooking and drinking) |
| Catchment area ($m^2$) | 3297.6 | Operational since (year) | 2007 |

**Background**

Kagarama secondary school is quite famous in Kigali as it is one of the old public schools with a total area of 4.5 hectares. The school is located in a populated Kagarama sector of Kicukiro district of Kigali having an estimated terrain elevation above sea level of 1544 metres. Kagarama is one of the least populated sectors in Kicukiro district, representing 4.5% of the total resident population of Kicukiro district.[46]

**Water Scenario**

The current water demand in the school is dependent on municipal supply (WASAC) and harvested rain. The water caters to a total strength of 1010 students and 64 staff. Out of which, 800 students and 15 supporting staff use the hostel facility. Per month the school pays a total bill of 300,000 RWF to WASAC for water supply. The water shortage is usually noticed in dry season especially between the months of July and August.

**Rainwater harvesting system**

Rooftop RWH system was implemented in 2007 as a retrofit to the existing building. The tanks constructed for storing rainwater harvested were partially funded by RWFA under Rwanda's Green Fund (FONERWA project).[47] Rainwater from the iron roofs is stored in underground ferrocement tanks and ground level plastic tanks (See Table 4.4). Runoff from the rooftop catchment areas of 6 blocks is stored in underground tanks after passing through a 2 chambered tank. The first chamber of this tank is the settler with size 3.6 $m^3$, so that silt and solid particles are taken care off. The other chamber has 800kg of sand which ensures the filtration of the harvested water. The filtered water from the underground tank is fetched using peddle pump.

Being a boarding school, the rainwater is used for all other purposes except for drinking and cooking, while the overflow is channelized in the drainage system.

**Table 4.4: Type of storage systems in GS Kagarama school**

| S. No. | Type of storage | Positioning | Capacity |
|---|---|---|---|
| 1. | Plastic tanks (5 in total) | Ground Level | 5 $m^3$ (each) |
| 2. | Plastic tanks (5 in total) | Ground Level | 10 $m^3$ (each) |
| 3. | Ferrocement (2 in total) | Under ground Level | 200 $m^3$ (each) |

*Source: CSE survey, 2018*

**Conveyance of the RWH system**

*Source: CSE, 2018*

**Underground storage tank with sand filters**

**Above ground plastic storage tank**

*Source: CSE, 2018*

**Operation and Maintenance**

The first flush system is installed before the storage tanks to discard first two spells of rainwater in order to ensure the quality of harvested water. Further sand filters are present in the ferrocement tanks to provide additional level of filtration. The gutters are occasionally cleaned and checked to prevent clogging of water. The supporting staff is responsible for the O&M, approximately 50,000 RWF is used monthly for replacing any broken part.

'The supporting staff are aware of RWH. There is no resentment/ hindrance in using the rainwater. Rainwater helps to meet the demand, previously they used to fetch water from long distance or tankers. Also they don't face any water quality problem.'
*Alice, Cleaner*

**Socio-economic and environmental benefits**

The aim of implementing RWH system at the school was not only to reduce erosion but also to bring down municipal water bill. Before the implementation of RWH system, the school was also dependent on tankers apart from WASAC. Every month 4 tankers with 16 $m^3$ capacity delivered water for a price of 70,000 RWF per tank. Once the RWH system was installed, water tankers were not needed. Further, the supporting staff were relieved from the long waits of receiving water from tankers and travelling long distances to fetch water.

The harvested water is used in maintaining the lush green lawns (1.4 Hectares), hence improving the micro environment and enhancing the aesthetics of the school. The RWH system implemented on the campus has become a platform for creating awareness, information, dissemination and learning for students and visitors.

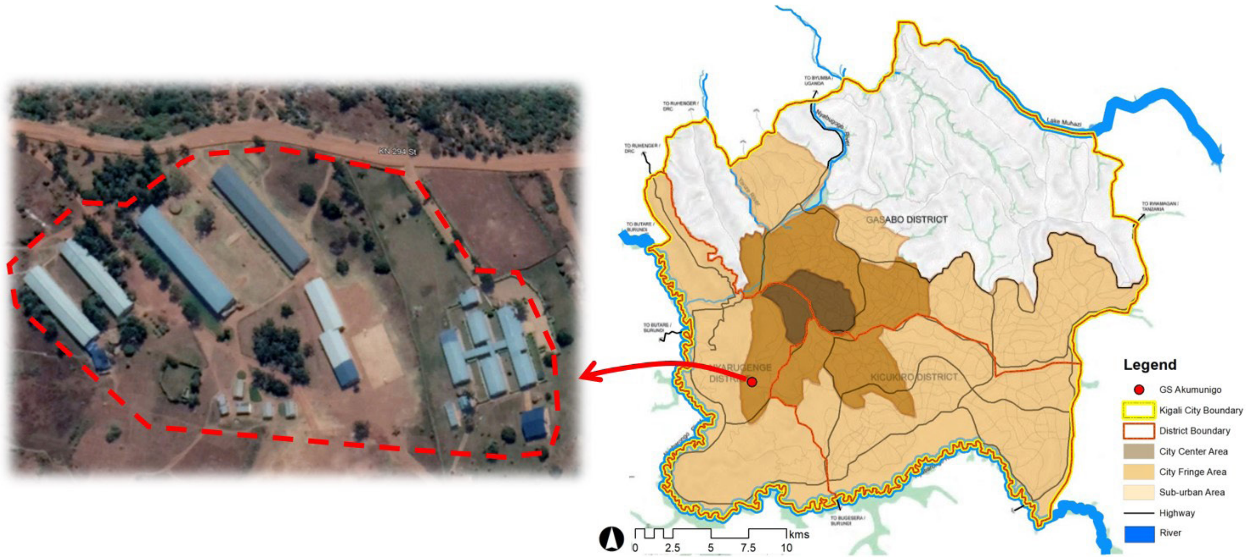
'The knowledge about the RWH system is well disseminated among the masses as people who visit the school see the system. Further, the students are aware of the system and its advantage as earlier due to shortage of water, they had to face many problems. No complaints from the students or staff on rainwater as it is approachable.'
*Nkurunziza Samuel, Principal*

**Green landscape of the school**

*Source: CSE, 2018*

### 4.1.4 GS Akumunigo Secondary School

**Location of GS Akumunigo school in Kigali city**




*Source: Google Map Image, 2018*

**Objective**
Two of the objectives of implementing the RWH system is to have an alternative source of water supply and protect the area from erosion.

**GS Akumunigo secondary school**

*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Nyamirambo sector, Nyarugenge district | Implementing organization | RWFA and District |
| Landuse | School, Institutional | Total volume of rainwater harvested annually ($m^3$) | 1595.28 |
| Total site area | 2.18 Hectares | Harvested water is used for | Non-potable purposes |
| Catchment area ($m^2$) | 2205 | Operational since (year) | 2005 |

**Background**

GS Akumunigo is an A level secondary school located in Rugarama village, Rugarama cell, Nyamirambo sector of Nyarugenge district, Kigali. Nyamirambo is one of the populated sectors in Nyarugenge district, accommodating 14.2% of the total population of district.[48] Since 1994, Nyamirambo has grown into a business hub and is referred to as the town that never sleeps.

**Water Scenario**

The current water demand in the school is dependent on municipal supply (WASAC) and harvested rain. Although the water supply from WASAC is regulated, per month 30-40 $m^3$ is supplied at a cost of 20,000 RWF. During the dry season, the municipal water supply is low as per the demand, which is being substituted by rainwater harvested within the school. The rainwater is being used for non-potable purposes, which constitutes the major part of the total water demand. The harvested water meets the demand for the strength of 1131 students in primary school (584 boys and 547 girls) and 564 students of the secondary school (280 boys and 284 girls), and a total of 50 staff and supporting staff.

**Rainwater harvesting system**

The total rooftop catchment area is around 2205 $m^2$. One masonry tank (above ground level) was installed during the construction of the school building in 2005. Once the funds were procured from the district and RWFA (under FONERWA project) rest of the tanks were installed in 2016 (See Table 4.5).[49]

**Table 4.5: Type of storage systems in GS Akumunigo school**

| S. No. | Type of storage | Positioning | Capacity |
|---|---|---|---|
| 1. | Plastic tanks (1 in total) | Ground Level | 10 $m^3$ (each) |
| 2. | Plastic tanks (3 in total) | Ground Level | 5 $m^3$ (each) |
| 3. | Masonry (2 in total) | Ground Level | 45 $m^3$ (each) |
| 4. | Metallic tanks (1 in total) | Ground Level | 3.5 $m^3$ (each) |

*Source: CSE survey, 2018*

To ensure that the first spell of rainfall is not used, first flush system is installed before the masonry tanks. Also the masonry tanks have a sand and stone filter before the water is fetch from the tanks. The water from masonry tanks is sometimes used for cooking mid-day meals to students.

**Above ground masonry storage tank**

**Above ground plastic storage tank**

*Source: CSE, 2018*

**Operation and maintenance**
The masonry tanks are cleaned manually once a year. The plastic tanks are cleaned more often at least 4–5 times a year. The rooftop catchment areas are difficult to access for cleaning purposes, however the gutters are cleaned as and when required. The job profile of the supporting staff includes the component of O&M of the RWH system.

**Conveyance system along with first flush**

*Source: CSE, 2018*

**Socio-economic and environmental benefits**

The RWH system installed in the school has provided substantial contribution in reduction of water cost paid to WASAC, especially during peak season. The water bill is now reduced to 20,000 RWF from 50,000 RWF per month. The augmentation in water availability has also contributed in prevention of erosion and maintenance of lush green landscape within the school boundary. The RWH intervention has multiple benefits not only it helps in keeping the school clean but also provides water to its nearby households. In order to disseminate the importance of water resources and various nature based solutions, a course on rainwater is introduced in the primary school under science and environmental technology course.

'The implementation of RWH structures has brought lot of ease, there is enough water to take care of various activities in the school.'
*Micheal, Supporting staff*

'One of the important changes, which rainwater brought was that some of the neighbours have replicated the system in their households.'
*Nzabandora Hildegand, Principal*

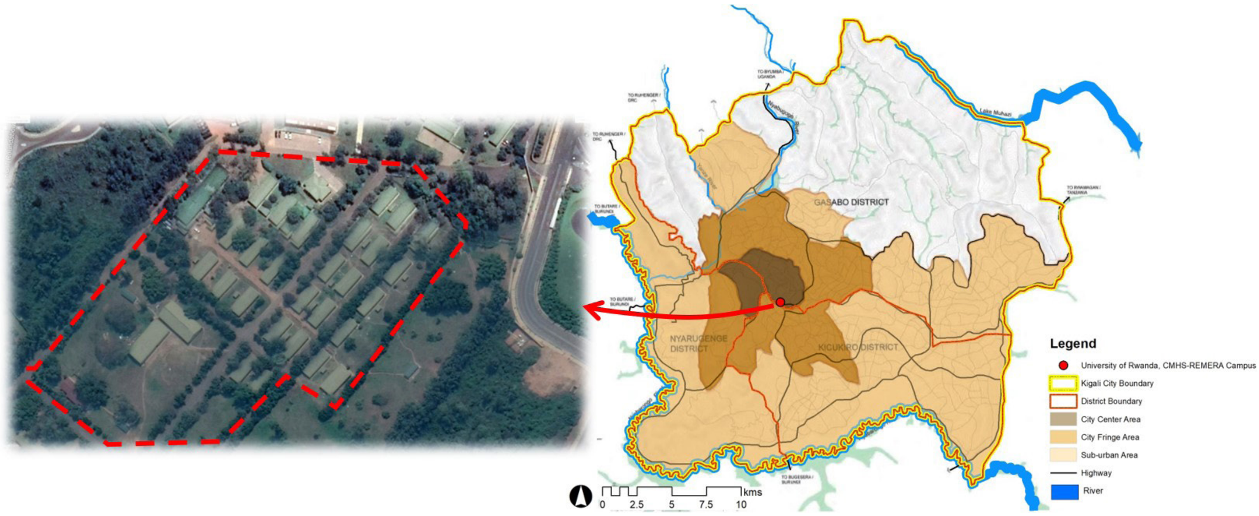
**Collected rainwater is being used to irrigate the green landscape**

*Source: CSE, 2018*

## 4.2 RWH system in public semi-public landuse

### 4.2.1 CMHS-REMERA campus, University of Rwanda

**Location of CMHS-REMERA campus in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The objective of implementing RWH system is to have an alternate water source in order to reduce the municipal water demand.

**CMHS-REMERA campus, University of Rwanda**

*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Remera sector, Gasabo district | Implementing organization | University of Rwanda - Remera Campus |
| Landuse | University, public-semi public | Total volume of rainwater harvested annually ($m^3$) | 5875.35 |
| Total site area | 17 Hectares | Harvested water is used for | All purposes (except cooking and drinking) |
| Catchment area ($m^2$) | 6891 | Operational since (year) | 2014 |

### Background

The University of Rwanda–Remera Campus is located in Remera sector which is an entirely urban sector of Gasabo district. The total area of the university is 17 hectares. The university accommodates a total of 4045 students and 284 staff.

### Water scenario

The daily water demand in the campus is between 44 $m^3$–60 $m^3$ which is met by municipal supply and RWH. However, the water supply from WASAC is not regulated at times the supply is for 2 hours per day. The per month cost of WASAC water supply is 847 RWF/$m^3$.

### Rainwater harvesting

The rooftop RWH system was implemented in 2014 at the university. While a few of the old buildings underwent retro fitting, the RWH system was inbuilt in the new buildings. Before the installation of RWH system, the school was partially depended on water supply from tankers. However due to the sustainability of RWH system the water was sufficient to avoid other private sources of water. The rooftop catchment area is given below (See Table 4.6).

'RWH has not only helped in reducing the demand of water by WASAC and tankers but also helped in maintaining a hygienic environment in the campus.'
*Christian Mucyo, Estate Manager*

**Table 4.6: Roof catchment area of CMHS-REMERA campus**

| Building | Length (m) | Width (m) | Area ($m^2$) |
|---|---|---|---|
| Inclusive classes | 94 | 9 | 846 |
| Harvard classes | 58.5 | 10.5 | 614.25 |
| Sall | 40 | 14.5 | 580 |
| Harvard Hall | 48.5 | 39.5 | 1915.75 |
| New building | 58.5 | 10 | 585 |
| Block 1 | 45 | 10 | 450 |
| Block 2 | 47.5 | 10 | 475 |
| Girl's hostel | 40 | 15 | 600 |
| Block 3 | 55 | 15 | 825 |

*Source: CSE survey, 2018*

In total there are 10 storage tanks ranging from masonry, metallic to plastic in the campus (See table 4.7). The harvested water is used for all purposes except drinking and cooking.

**Table 4.7: Type of storage systems in CMHS-REMERA campus**

| S. No. | Type of Storage | Positioning | Capacity |
|---|---|---|---|
| 1. | Plastic tanks (4 in total) | Ground Level | 3 x 10 $m^3$ (each) and 1 x 5 $m^3$ |
| 2. | Masonry (4 in total) | Under Ground Level | 2 x 20 $m^3$ and 2 x 5 $m^3$ |
| 3. | Metallic tanks (2 in total) | Ground Level | 10 $m^3$ (each) |

*Source: CSE survey, 2018*

**Above ground level plastic storage tank**

**Above ground level metallic tank**

*Source: CSE, 2018*

**Operation and Maintenance**
Minimal operation and maintenance of the RWH system is being practiced in the campus. There is no provision of discarding the first spell of rain. Once a year, the tanks are washed manually. The gutters are cleaned occasionally to prevent incidences of water clogging.

**Conveyance system**

*Source: CSE, 2018*

**Socio-economic and environmental benefits**
The campus is stretched to about 17 hectares comprising of playground and lawns. Due to the availability of water the green area of the campus is maintained all through the year. The RWH system has reduced the dependence on municipal water supply and private tankers. It has also helped in maintaining the cleanliness and hygiene within the campus. Also the intervention has reduced the time and stress to call the tankers.

However efforts need to be taken to initiate programmes, seminars to emphasiz the importance of RWH among students who will help in awareness creation of the concept of RWH. The RWH project implemented in the university can become a high visibility, high impact intervention site with considerable social and economic benefits to direct users as well as its surrounding environment in terms of improvement in micro climate.

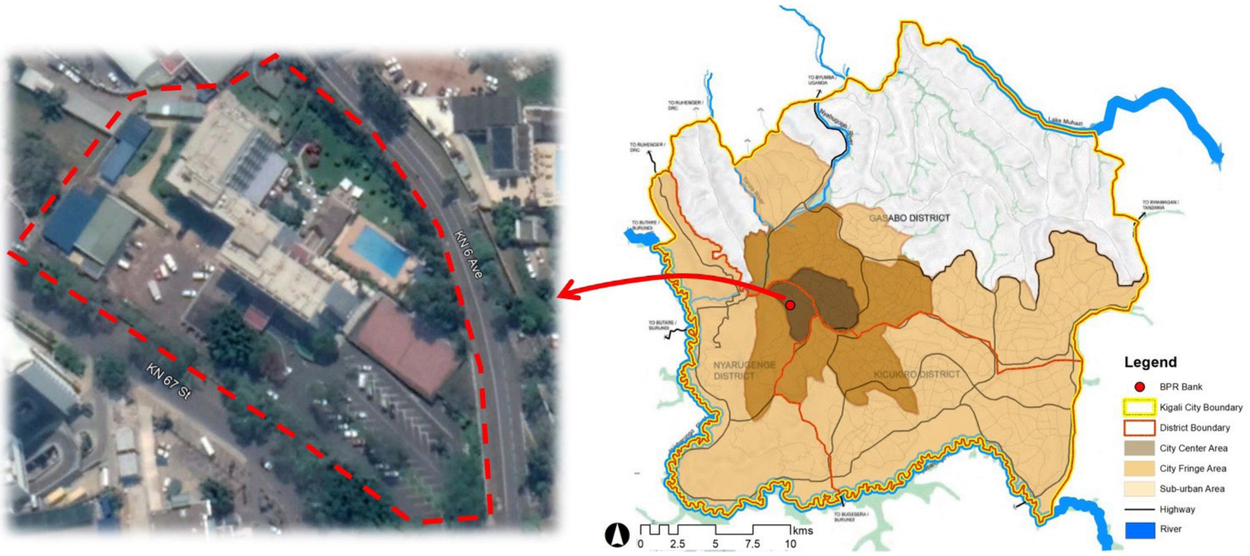
'The RWH system is serving as an alternate source of water. Due to which dependence on municipal supply has decreased. The university has a department of environment which has a course on RWH. They are aware of the system rest hardly anyone knows. Percentage of awareness of RWH is low in the campus.'
*Christian Mucyo, Estate Manager*

**Green landscape irrigated by harvested rainwater**

*Source: CSE, 2018*

## 4.2.2 BPR part of Atlasmara

**Location of BPR part of Atlasmara in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of installing RWH system in this office complex is to reduce the cost of water from municipal supply at a smallscale building level.

**BPR part of Atlasmara, Kigali**

| Salient features | | | |
|---|---|---|---|
| Location | Nyarugenge district | Implementing organization: | BPR Bank |
| Landuse | Bank, public semi public | Total volume of rainwater harvested annually ($m^3$) | 460.7 |
| Total site area | N/A | Harvested water is used for | Floor mopping and toilet flushing |
| Catchment area ($m^2$) | 600 | Operational since (year) | 1984 |

**Background**

BPR is the largest banking network in Rwanda and part of Atlasmara group. They have 193 branches and 105 ATM locations countrywide, with this they remain easily accessible and offer convenience to the customers to meet their financial and banking service needs.[50]

In the context of RWH case study, the branch in discussion is located in Nyarugenge district of CoK. The building was constructed in 1984.

**Water scenario**

The existing water supply sources for the bank include municipal water supply from WASAC and rainwater harvesting. The daily demand of water for about 100 staff and 50–70 customers is approximately 10,000 L per day. The bank pays around 120,000 RWF as water bill per month to WASAC.

**Rainwater harvesting system**

The rooftop RWH was implemented the same year when the building was constructed in 1984. The rooftop with an area of 600 m$^2$ (approx.) is the catchment for harvesting rain. The rainwater is stored in two metallic tanks of 5000 L each installed on the mezzanine floor of the bathrooms in two different wings. However when there is no rain, the tanks are filled with WASAC water. The harvested water is used for flushing and floor mopping.

### Storage tank situated in mezzanine floor

*Source: CSE, 2018*

**Operation and maintenance**

In terms of maintenance, a trap is placed at the top of the storage tanks so that solids are filtered out. The tanks are cleaned manually after every 3 months. The gutters are cleaned as per requirement. The supporting staff is responsible for the maintenance of the system apart from their regular work profile.

**Access to storage tank located in mezzanine floor**

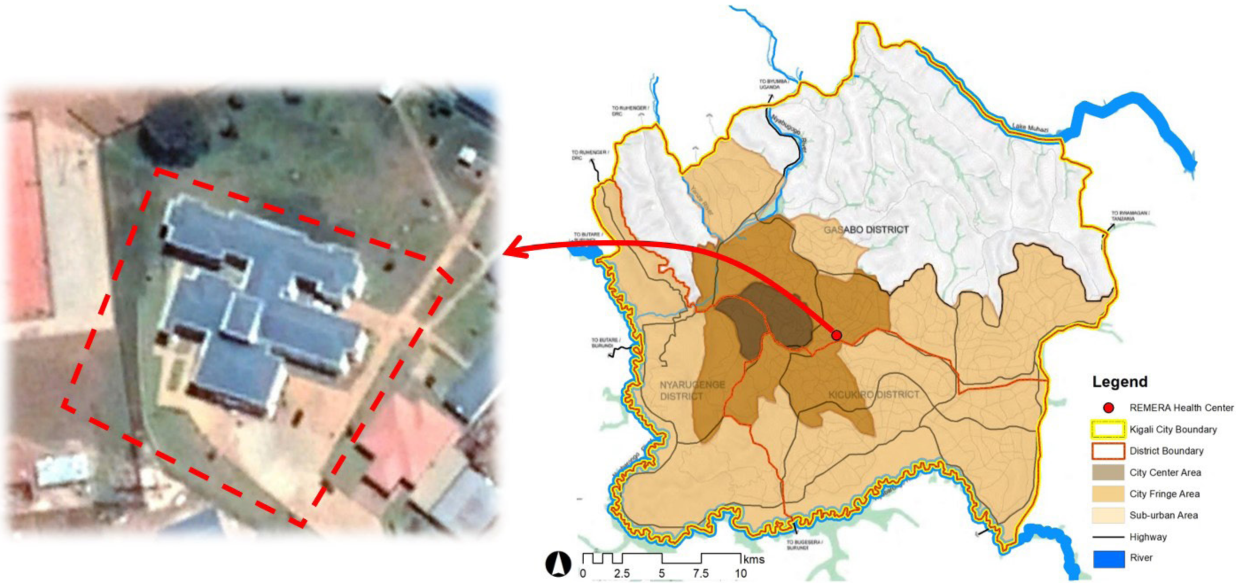
*Source: CSE, 2018*

**Socio-economic and environmental benefits**

The case example showcases an innovative approach of ensuring that maximum runoff from the roof is harvested and used within the site. This practice needs to be disseminated in other commercial areas where space is a constraint. Each unit of water conserved in this building through RWH has a corresponding saving in the water bill. However, there is a need to sensitize the staff about the potential of RWH as the staff are not aware of the system.

### 4.2.3 Remera Health Centre, Kigali

**Location of Remera Health Center in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The main objective of implementing RWH intervention is to meet the growing demand of water supply in the centre and to reduce municipal water bill.

**Remera Health Centre, Kigali**


*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Remera sector, Gasabo district | Implementing organization | Belgium Technical Cooperation |
| Landuse | Health centre, public- semi public | Total volume of rainwater harvested annually ($m^3$) | 1270.75 |
| Total site area | 1.12 Hectares | Harvested water is used for | All purposes (except cooking and drinking) |
| Catchment area ($m^2$) | 1495 | Operational since (year) | 2011 |

**Background**

The health centre was constructed in 2011 in the Remera sector of Gasabo district with the main objective of promoting health services in the area. The construction of the health centre is in line with the district's plans to extend health facilities to all residents in the entire district. The construction cost of the centre is about RWF 665 million, which was funded by Belgium Technical Cooperation.

**Water scenario**

The centre is dependent on WASAC as well as rainwater for water supply catering to approximately 400 patients per day and 65 staff. The monthly water drawn from WASAC is about 236 $m^3$ at a cost of 200,000 RWF.

**Rainwater harvesting system**

The rooftop RWH system was implemented in 2011 during the construction of the centre. There are two underground tanks (8m deep) one for storing water from municipal supply (WASAC) and one for storing harvested rainwater. Harvested water is supplied to the distribution tanks (plastic tanks) of 5,000 L capacity. At times when the water in the storage tank is full, the harvested water is directly distributed from the plastic tanks. Approximately there are 6 plastic distribution tanks in the centre. The harvested water is used for floor mopping (twice a day), washing clothes, horticulture and flushing (using buckets).

### Distribution tank before underground storage tank

*Source: CSE, 2018*

**Conveyance system for rooftop to horizontal open channels**

**Access to underground storage tank**

*Source: CSE, 2018*

**Operation and maintenance**

In terms of O&M, the centre needs to make more deliberate efforts to sensitize the staff. This will help in keeping the system sustainable for a longer period of time. At the moment there is no regular protocol for O&M, since the construction of the system the tanks have been cleaned only once.

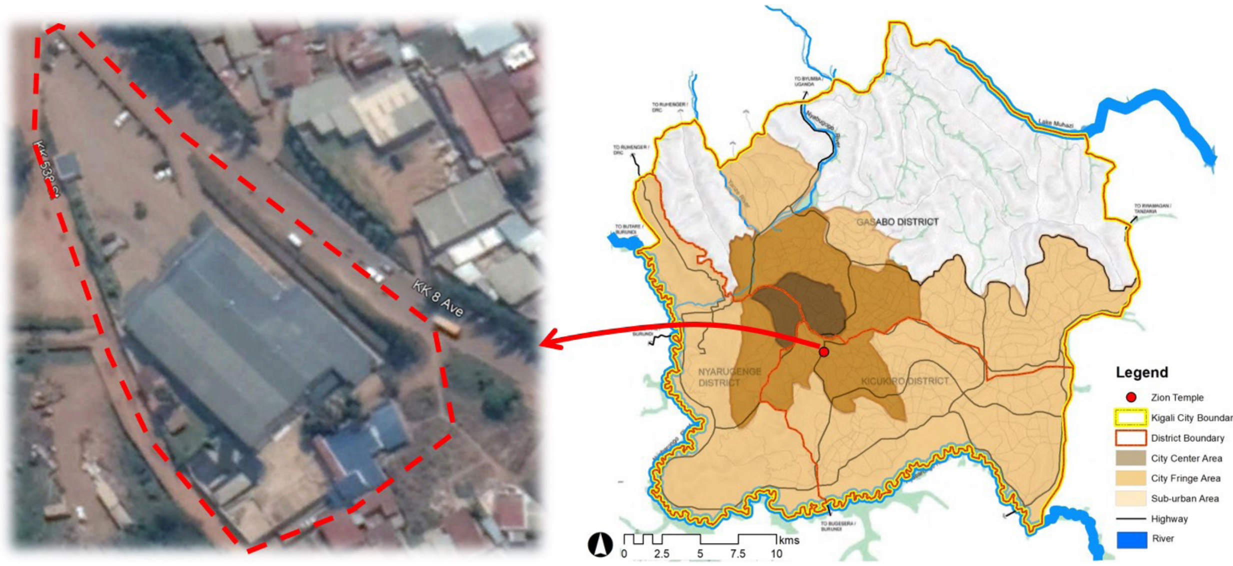
**Socio-economic and environmental benefits**

The RWH project is a high visible and high impact intervention with considerable social and economic benefits to direct users as well as its surrounding environment in terms of improvement in micro climate.[51] At an institutional scale, the system contributes toward the resource conservation. The reduced pressure on the public water supply system has a positive environmental impact. The system also earns carbon credit in terms of energy conservation for in-situ water augmentation on centre instead of sourcing water from distant sources of water supply. The increase in availability of water has not just contributed towards maintaining lush green landscape of the centre but also helped in keeping the premises clean.

'The presence of RWH intervention has helped to keep the centre clean and also to reduce the municipal water supply demand.'
*Muzungu Christion, Administration Division*

### 4.2.4 Zion Temple Celebration Centre

**Location of Zion Temple Celebration Centre in Kigali city**




*Source: Google Map Image, 2018*

**Objective**
The purpose of installing the system is to have a secondary source of water supply apart from municipal water supply.

**Zion Temple Celebration Centre, Kigali**


*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Kicukiro district | Implementing organization | Zion Temple Worship Centres |
| Landuse | Temple, public-semi public | Total volume of rainwater harvested Annually ($m^3$) | 1626.9 |
| Total site area | 0.57 Ha | Harvested water is used for | Floor mopping and flushing |
| Catchment area ($m^2$) | 1914 | Operational since (year) | 2011 |

**Background**
Zion Temple Worship Centres are revival–driven Churches planted by the Authentic Word Ministries International around the world. The centre was built in 1999 and is located in Kicukiro district of Kigali. Approximately, 300 visitors visit the centre in a day.

**Water scenario**
The temple is dependent for water demand on municipal supply water. However, the temple does have a rooftop RWH system but only a fraction of harvested water is collected and stored.

**Rainwater harvesting system**
A total of approximately 1,914 $m^2$ is the rooftop catchment area for RWH. However, a 10 $m^3$ capacity of plastic tank is used to harvest rain water while rest of the runoff is drained into stormwater channels. The harvested water is used for floor mopping and flushing.

### Storage tank for rainwater collection

*Source: CSE, 2018*

### Conveyance system

*Source: CSE, 2018*

**Operation and Maintenance**

Apart from the caretaker, the staff is barely aware of the system. Further the requisite information of the water supply and RWH is not available. There is no mechanism for first flush system to prevent the first two spell of polluted rainfall to enter the storage tank.

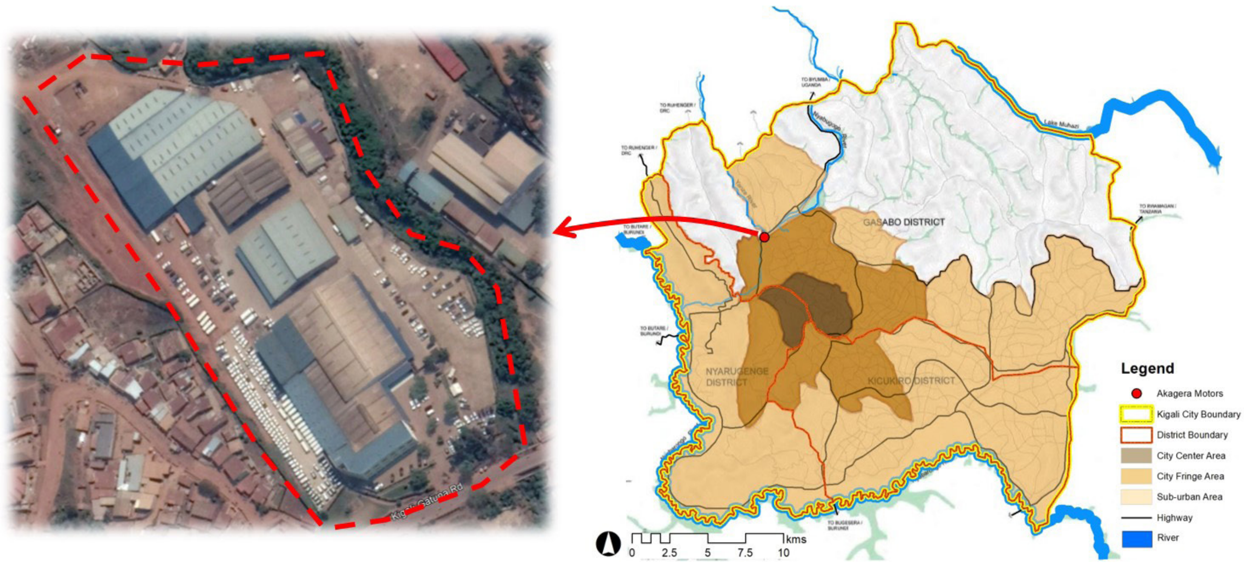
**Socio-economic and environmental benefits**

The system implemented at the temple is an example of partial use of potential runoff generated with missed opportunity to harvest more rainwater. Being a high visibility and high impact site where 300 people visit every day, the use of RWH system could create awareness for such interventions. This site can become a future platform for dissemination of the efficient use of RWH system.

## 4.3 RWH system in small scale industries and hotel

### 4.3.1 Akagera Motors

**Location of Akagera Motors in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of implementing RWH system is to reduce the dependence on municipal water supply by using the alternative source of water for low end use in the centre.

**Akagera Motors, Kigali**


*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Gasabo district | Implementing organization | Akargera Motors |
| Landuse | Car wash and showroom, Industrial landuse | Total volume of rainwater harvested annually ($m^3$) | 6147.85 |
| Total site area | 7 Hectares | Harvested water is used for | Car washing and flushing |
| Catchment area ($m^2$) | 3500 | Operational since (year) | 2013 |

**Background**

Established in 1997, Akagera Motors is the exclusive distributor for Toyota (Japan), HINO (Japan), Mahindra & Mahindra (India) and Ashok Leyland (India). Akagera Motors is responsible for revolutionizing the public transport sector of Rwanda by being the first to offer vehicle financial leasing for medium and large size buses.[52] It is situated on the Kigali–Gatuna road of the Gasabo district of Kigali. The first building was constructed in 1981. The total area of the centre is 7 hectares.

**Water scenario**

The centre is dependent on municipal water supply (WASAC) as well as rainwater for water supply to cater to about 350 employees, 500 visitors per day and 3 carwash unit. Monthly 250,000 RWF is paid as water bill to WASAC. The rainwater is used for car washing and at times for flushing.

**Rainwater harvesting system**

During the expansion of the centre in 2013, RWH system was implemented taking into account the water demand for 3 carwash units. On an average 70–100 cars are being washed per day. The catchment area of the centre includes surface area of the site as well as the rooftop areas of few buildings. The total area of the rooftop catchment is approximately 3500 m$^2$. The rooftop rainwater is stored in a stainless-steel tank of 40,000 L. The tank was basically a trailer which has been transformed into a RWH tank, costing around 5 million RWF. They are in the process of transforming one more trailer into a storage tank. In addition, there are 3 plastic tanks of 5000 L (each), costing around 2 million RWF which store harvested water from the rooftop catchment areas.

Further, an underground tank of 10,000 L stores water from the surface catchment area during rainfall. The runoff from paved surface is collected and also used for car washing. However, for the past 2 years the rainwater collected from surface runoff does not meet the quality requirements to clean the car's interiors hence only the exteriors of cars are cleaned using this stored rainwater.

### Above ground Plastic storage tanks


*Source: CSE, 2018*

### Trailers converted to storage tanks

*Source: CSE, 2018*

**Operation and maintenance**

The catchment area and the rain outlets are cleaned occasionally. There is no mechanism of the first flush system which avoids first spell of the polluted rainfall. The storage tanks are washed manually once in every three months. The supporting staff takes care of O&M, the component is added in their job profile.

**Horizontal open channels with screening for conveyance**

**Underground storage tank with pebbles**

*Source: CSE, 2018*

**Socio-economic and environmental benefits**

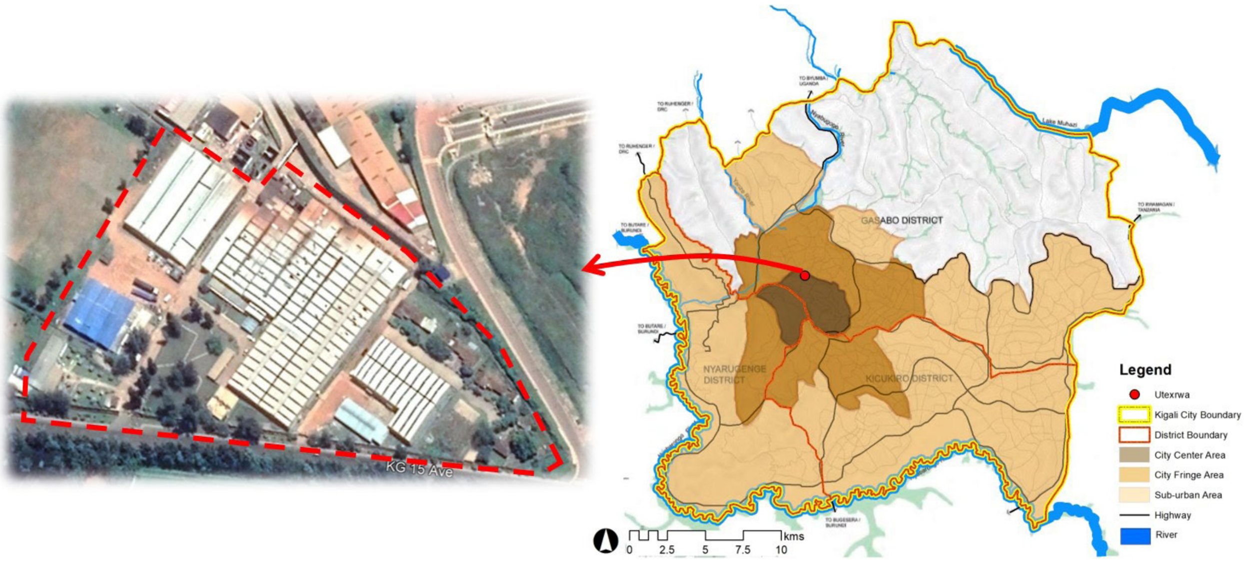
The RWH intervention in the motor centre is one of the good practices of arresting rooftop rainwater along with capturing of storm water runoff for low end uses. Further the transformation of the trailer into a storage tank is an innovative example of utilizing the existing resource. Thus paving the way for more novel ideas and harvesting rain not only at residential, hotel or universities but also at centres like motor carwash. The RWH intervention has provided huge economic benefit in terms of energy conservation for in-situ water augmentation. However, at the motor centre only the staff involved in car washing are aware of RWH while the rest of the staff is hardly aware of the existence of RWH system. This can be addressed by showcasing BMPs through advocacy and sensitization programmes.

'The staff working in the carwash unit are well aware of the RWH system. There has been no hesitation by them and also no incidence of any health problem has been reported.'
*Gilbert, Support staff*

'Due to high demand of water, the RWH system has helped the centre to reduce the cost of municipal supply.'
*Ishami Karamaga, Property Manager*

## 4.3.2 UTEXRWA SA

**Location of UTEXRWA SA in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of implementing RWH system is to reduce the water bill of municipal supply and prevent the property from waterlogging and erosion during the rainy season.

**UTEXRWA SA, Kigali**


*Source: Kigalikonnect.com*

| Salient features | | | |
|---|---|---|---|
| Location | Gasabo district | Implementing organization | Utexrwa |
| Landuse | Industry | Total volume of rainwater harvested annually ($m^3$) | 7647.45 |
| Total site area | 9.3 Hectares | Harvested water is used for | Processing of the textile fabric and toilet flushing |
| Catchment area ($m^2$) | 20,000 | Operational since (year) | 1984 |

**Background**
Utexrwa is a textile factory constructed in 1984 which offers its clients, the mass production from an extensive line of varieties of garments.[53] The factory is located in Gasabo district of Kigali with a total area of 9.3 hectares of which 70% is the green area. Total strength of the factory is 450 workers who work in shifts which can stretch to 2 days.

**Water scenario**
The factory is dependent on municipal supply (WASAC) as well as on RWH for its water demand. The factory is operational 8-12 days a month and the total daily demand for water is 25,000 to 50,000 L. Water from municipal supply is used for drinking, bathing and handwashing. While rainwater is used in processing of the fabric and toilet flushing. The average water bill from WASAC is 1 million RWF per month.

**Rainwater harvesting system**
The rooftop RWH intervention was implemented in 1984 with the construction of the factory. There are two concrete storage tanks, one underground with capacity of 3,200,000 L, another at ground level with capacity of 800,000 L. The area of the rooftop catchment is 20,000 $m^2$. The construction cost of the system is approximately RWF 178,659 per $m^2$.

**Underground storage tank**

*Source: CSE, 2018*

**Operation and maintenance**

The storage systems do not have the any filtration or first flush system to avoid dirt and debris entering into the system. The stored rainwater is primarily used in the processing of textiles. The harvested water is passed through the boiler to remove impurities before using it for textile manufacturing.

The RWH tank which is on the ground level is cleaned once a month ensuring to removal of suspended particles/material floating on the surface. The tank is thoroughly cleaned every 3 months. The component of maintaining the system is in built in the job profile of the supporting staff.

**Socio-economic and environmental benefits**

The RWH system in the textile factory is a good example of using an alternate source of water, where the dependence on municipal supply is only around 10–15%. Further the harvested water used in the processing is recycled and reused in the factory.

'The RWH intervention at factory level with such a huge reservoir is one of its kind in Kigali.'
*Ritesh Patel, Managing Director*

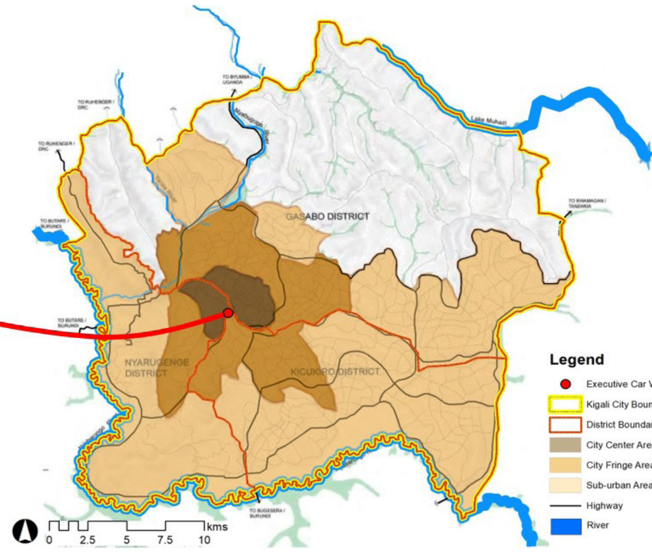
Across the globe, the demand for water harvesting systems is expected to increase as industrial building owners realize the benefit of capturing, storing, filtering and using harvested rainwater for multiple purposes. Water harvesting systems helps to reduce water bills and alleviate demand on municipal systems.[54] It therefore makes eminent sense for industries to harvest rainwater because it saves money and uses rain water productively.[55]

**Harvested water is used for processing of the textile fabric**

*Source: CSE, 2018*

### 4.3.3 PT Executive Car Wash

**Location of PT Executive Car Wash in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of implementing RWH system is to reduce the dependence on municipal water supply by using the alternative source of water for low end use in the centre.

| Salient features | | | |
|---|---|---|---|
| Location | Kacyiru sector, Gasabo district | Implementing organization | PT Executive Car Wash |
| Landuse | Industry | Total volume of rainwater harvested annually ($m^3$) | 410.9 |
| Total site area | 0.14 Hectares | Harvested water is used for | Car washing and toilet flushing |
| Catchment area ($m^2$) | 527 | Operational since (year) | 2005 |

**Background**

The car wash service centre is located in Kimihurura cell which lies in Kacyiru sector, the suburb neighbouring the presidential office and number of Rwanda' ministry offices. This sector lies in the Gasabo district.

**Water scenario**

The service centre is dependent on municipal supply (WASAC) as well as on RWH for its water demand. Per month 20-30 $m^3$ of WASAC water is consumed for which 16,000 RWF is paid as water bill to WASAC. A total of 5 storage tanks are installed to distribute the water supply received from WASAC and RWH system. Capacity of 4 tanks is 10,000 litres costing 450,000 RWF while the 5th is 5,000 litres costing 350,000 RWF.

**Rainwater harvesting system**

The RWH system was implemented in 2005 and since then it is running successfully. All the water i.e. rainwater from roofs and surface, and the reused water (used during car washing) is collected in an underground tank having a capacity of approximately 30m depth x 2m x 1.5m. Five sedimentation tanks (5m down and 40 m in diameter) before the storage tank is installed so that silt and solid particles are taken care off. Due to the presence of reuse water, the water from storage tank is passed into sand filters of 1.5 $m^3$ followed by UV rays chamber and then stored in 6 storage tanks of 10 m deep and 80 cm diameter. The stored water is used for all purposes except for drinking.

**Distribution tanks**

*Source: CSE, 2018*

**Operation and maintenance**
The system combines the process of treating wastewater along with rainwater, hence the O&M component holds a great importance. There is an intensive filtration process for treating and reusing wastewater along with rainwater. The catchment is cleaned as and when required. Further, after every two weeks the tanks are cleaned manually. The supporting staff is responsible for O&M.

**Sedimentation tanks**

**Filtration system**

*Source: CSE, 2018*

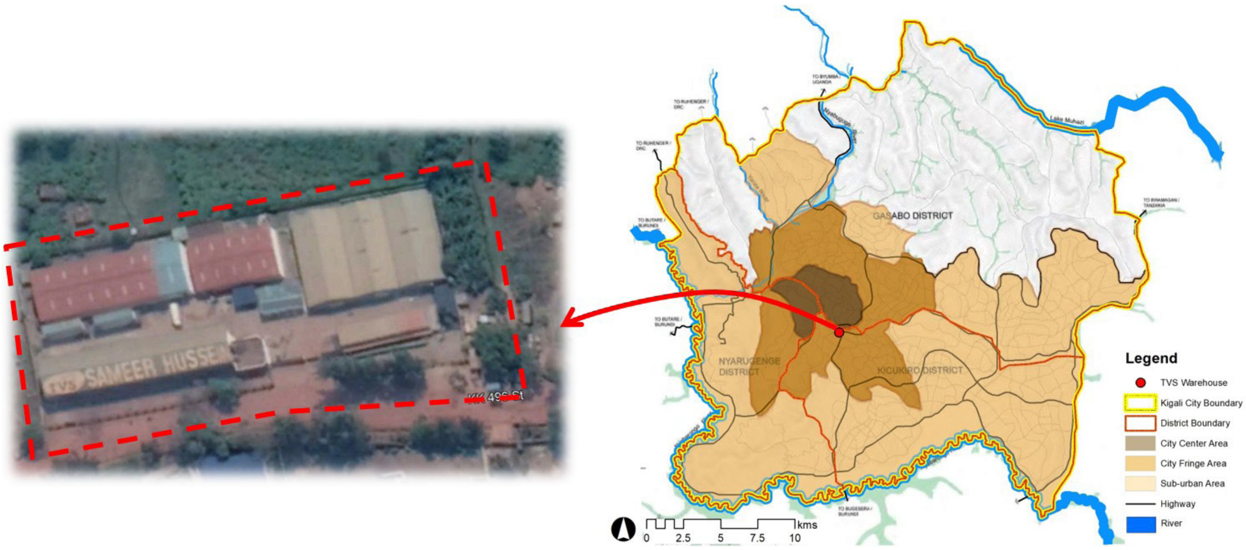
**Socio-economic and environmental benefits**
The implemented RWH system is a valuable resource cum facility for the carwash centre and demonstrates to other practitioners the value of rainwater and its potential use. It has not only provided economic benefits by reducing the water bills but also to the environment as a whole by reducing the carbon foot prints. Thus, in turn adding benefit to the water energy nexus.

'The aim of installing RWH system was to reduce the dependence on WASAC water supply. In the neighbourhood, no other car wash centre has RWH system implemented. The staff is aware of the type of water used and have not shown any resistance.'
*John, Manager*

'We have been using the treated water for long and have not faced any type of health issues.'
*Stephan, Staff*

### 4.3.4 TVS Warehouse

**Location of TVS Warehouse in Kigali city**




*Source: Google Map Image, 2018*

**Objective**
The key objective of implementing RWH system is to reduce the dependence on municipal water supply by using the alternative source of water for low end use in the centre.

**TVS Warehouse, Kigali**


*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Nyarugenge district | Implementing organization | TVS centre |
| Landuse | Industry | Total volume of rainwater harvested annually ($m^3$) | 1741.8 |
| Total site area | 2.56 Hectares | Harvested water is used for | All purposes (except cooking and drinking) |
| Catchment area ($m^2$) | 1500 | Operational since (year) | 1998 |

**Background**

TVS motors is the retailer selling TVS motor bikes in Kigali. It is a common name in Kigali which has its showroom and a warehouse. The warehouse is located in the Nyarugenge district and was constructed in 1998.

**Water scenario**

The warehouse is dependent on municipal water supply (WASAC) as well as rainwater for water supply. However, for the past two years due to the construction of national highway the warehouse has not received municipal water supply. Thus, apart from harvested rainwater the warehouse is dependent on the nearby compound water supply, catering to 15 families (3–4 person per family) residing in the warehouse and 40 staff working for 8 hours. The households pay 10,000 RWF per month as water bill for the compound water supply.

**Rainwater harvesting system**

The rooftop RWH structure was implemented approximately 20 years ago. Around 1500 $m^2$ is the rooftop catchment area for RWH. The harvested water is stored in 4 tanks of 1000 L each and 2 tanks of 2000 L capacity. Further the surface runoff is collected and stored in two underground storage tanks each of 10,000 L capacity. The harvested water is used for floor mopping, toilet flushing (using buckets) and horticulture purposes.

**Operation and maintenance**

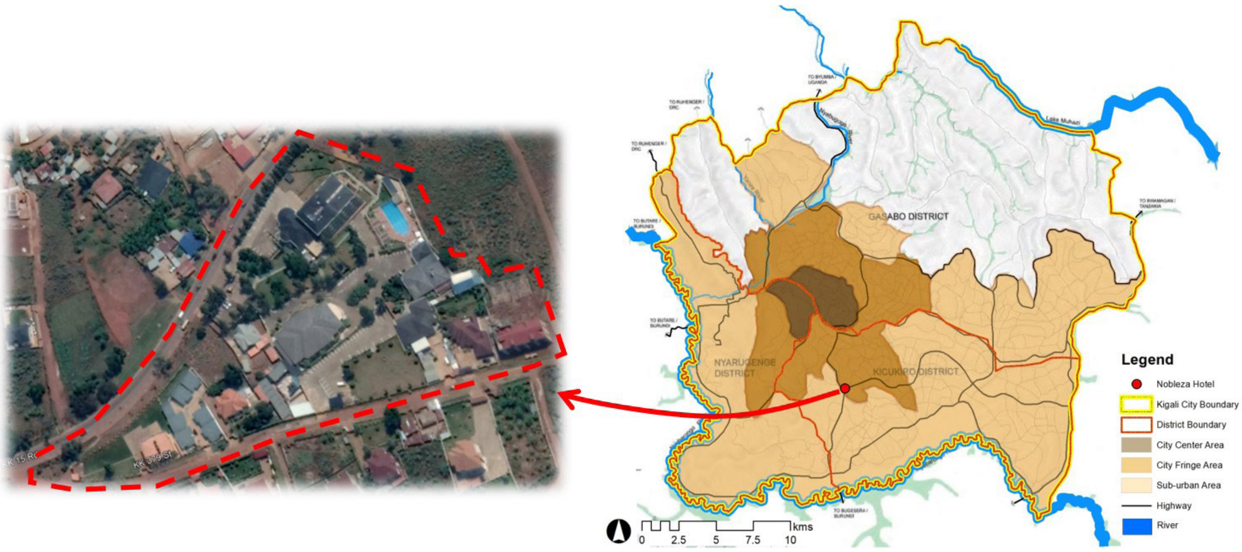
In terms of maintenance, basic level of O&M for the RWH structures is being done. The tanks are cleaned manually once a month. The gutters are cleaned as per requirement.

**Socio-economic and environmental benefits**

Although, the system provides social and economic benefits it has a huge potential to retai more harvested water that can be used within the centre and also provided to the neighbours. Currently, the area does not receive municipal water supply, thus implementation of rainwater systems can be of benefit. Also there is a need to sensitize the staff and families residing in the warehouse about the potential of RWH to make the system sustainable.

### 4.3.5 Hotel Nobleza

**Location of Hotel Nobleza in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The objective of the RWH intervention in the hotel is to avoid water logging by reducing the surface runoff and also using a fraction of harvested water for horticulture.

**Hotel Nobleza, Kigali**

*Source: CSE, 2018*

| **Salient features** | | | |
|---|---|---|---|
| Location | Kicukiro district | Implementing organization | Hotel Nobleza |
| Landuse | Hotel | Total volume of rainwater harvested annually ($m^3$) | 846.46 |
| Total site area | 2 Hectares | Harvested water is used for | Horticulture |
| Catchment area ($m^2$) | 996 | Operational since (year) | 2010 |

**Background**

Nobleza Hotel is a lodge with elegant architecture, located in Kicukiro centre of Kicukiro district, just 15 minutes from Kigali International Airport. The total area of the hotel is two hectares.

**Water Scenario**

The hotel is majorly dependent on WASAC municipal supply for its water demand. With an influx of around 200 person per day, approximately 116 $m^3$ is the municipal water demand per month. For this water demand the hotel pays 700,000 RWF to WASAC as water bill per month.

**Rainwater harvesting system**

Since 2010, the hotel practices RWH by recharging it into the ground as well as storing the harvested rainwater from rooftop. Over the years, with the expansion of the hotel, more pits have been constructed to cater the additional runoff. From all the surface catchment areas, runoff is directed to 8 soakaway pits of 20 m depth. The cost of pits is 400,000 RWF. However, from the main building rooftop rainwater is stored in a storage tank of 80 $m^3$ capacity which is further used for horticulture purposes through pumping.

**Storage tank**

*Source: CSE, 2018*

**Operation and Maintenance**

There is minimal O&M practised, the catchment and gutters are cleaned occasionally as and when required.

**Conveyance system for runoff**

*Source: CSE, 2018*

**Socio-economic and environmental benefits**

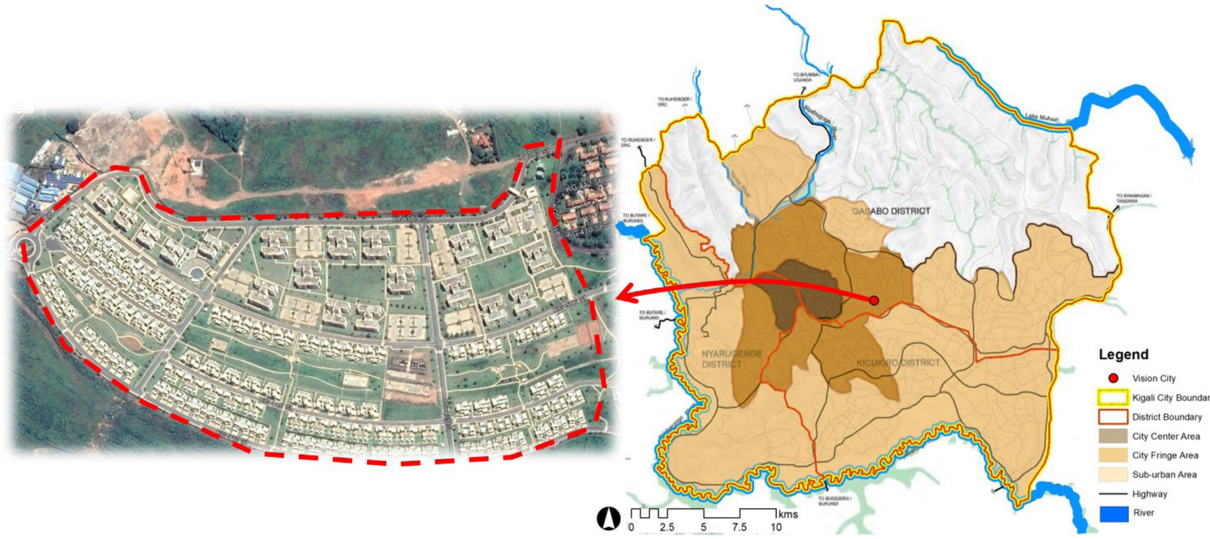
The hotel is unaware of the benefits of the RWH system. There is no record/ track to what extent the rainwater is recharged or has there been increase in groundwater after the intervention of the system. Moreover, apart from the estate manager and the gardener, rest of the staff was not aware of such a system on the premises.

'There are apprehensions in using rainwater in hotels thus it's been drained off.'
*Estate Manager*

## 4.4 RWH system in neighbourhood/housing

### 4.4.1 Vision City Phase 1

**Location of Vision City Phase 1 in Kigali city**




*Source: Google Map Image, 2018*

**Objective**

The key objective of implementation of RWH system is to use rainwater as an alternate source of water in the residential development.

**Vision City Phase 1, Kigali**

*Source: realestate.co.rw*

| Salient features | | | |
|---|---|---|---|
| Location | Kinyinya sector, Gasabo district | Implementing organization | Rwanda Social Security Board |
| Landuse | Housing | Total volume of rainwater harvested annually ($m^3$) | 11085.7 |
| Total site area | 32 Hectares | Harvested water is used for | Horticulture |
| Catchment area ($m^2$) | 13042 | Operational since (year) | 2017 |

**Background**

Vision City is a multi-phase housing development in Kigali, Rwanda currently being built by Ultimate Developers LTD for the Rwanda Social Security Board (RSSB). There are 4500 units to cater 22,000 people, and is considered as one of the largest residential housing projects in the country.[56,57]

This residential housing project is situated in the uptown neighborhood of Gacuriro cell, Kinyinya sector in Kigali's Gasabo district. The project is just 3 km from the CBD and 6 km from Kigali International Airport, and offers a wide range of housing typologies.

The first phase with a total area of 32 hectare consisting of 504 units was built in 2017 with around 30% initial occupancy.[58]

**Water scenario**

The housing is dependent on municipal supply (WASAC) for its water demand. As per the proposal the developer has promised to supply more than 110 litre per person per day (lpcd) to the occupants.

**Conduit pipes as conveyance system for capturing the runoff**

*Source: CSE, 2018*

**Rainwater harvesting system**

The rainwater is collected from iron roofs (rooftop catchment areas) of 19 buildings with approximate area of 50x50 $m^2$. The harvested water is further stored in a tank downhill through gravity and is presently used for irrigating the lawn. The capacity of the underground storage tank is 1250 $m^3$. The harvested water from the storage tank is passed through a high level of filtration system comprising of chlorine chamber, four sand filters and one carbon filter before use.

An expensive system of filtration is used with the future planning of treating the water to the drinking level standards, so that it can be added in the water network of the housing society along with municipal supply from WASAC. However for doing so, permission from WASAC is required based on the water quality testing to be conducted by WASAC. Hence, if the quality of water falls under the drinking water standards then the developer will be allowed to use rainwater in the water supply. At present, this stored water is only used for horticulture purposes for a lawn area of 95,000 $m^2$.

**Socio-economic and environmental benefits**

The residential complex has been functional for one year. However as the filtration system is complex, focus on O&M needs to be more deliberate by employing a trained staff. It is important to include the beneficiaries in the activity. During the survey and KII it was found that the residents are aware of the system as they have to pay for the O&M activities conducted for RWH system, which is a step towards awareness and sensitization of nature based solutions

At present the harvested water is used for horticulture purpose thus enhancing the microclimate of the area. As the project is first of its kind in Kigali, it has opened ways for new developers to think more on the aspect of sustainability.

**Filtration system**

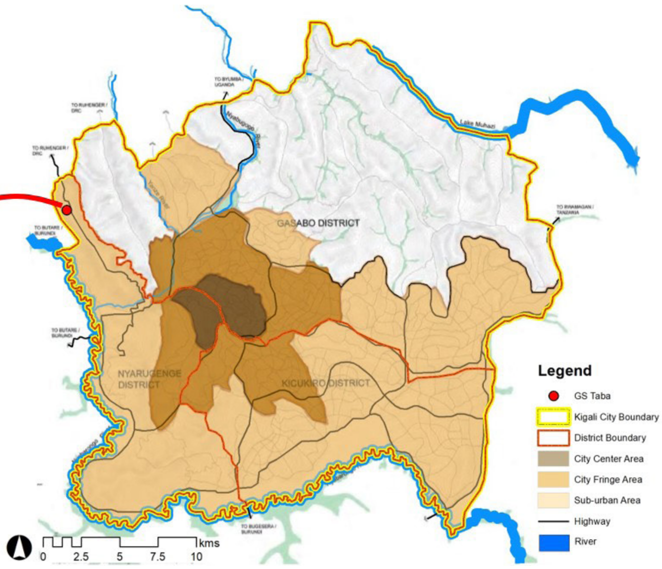
*Source: CSE, 2018*

'The RWH system installed in the vision city is purely on the basis of choice as there is no enforcement for the intervention. The challenge lies in the cost, if the private developer has to implement RWH it is an extra cost. Thus the scaling of such a system is limited.'
*Designing and RWH supervision, Synergy Pvt Limited*

'The residents of the vision city are well informed about the RWH system. At the moment the harvested water is used to maintain the greenery of the area.'
*China civil and engineer construction cooperation*

## 4.4.2 Taba Grouped Settlement

### Location of Taba Grouped Settlement in Kigali city


*Source: Google Map Image, 2018*

**Objective**

The main objective of implementing RWH system in the settlement is to have a source of water supply along with preventing soil erosion in the area.

### Taba Grouped Settlement. Kigali

*Source: CSE, 2018*

| Salient features | | | |
|---|---|---|---|
| Location | Kanyinya sector, Nyarugenge district | Implementing organization | RWFA |
| Landuse | Housing | Total volume of rainwater harvested annually ($m^3$) | 3360.6 |
| Total site area | 1 Hectares | Harvested water is used for | All purposes, except drinking |
| Catchment area ($m^2$) | 3953.6 | Operational since (year) | 2016 |

**Background**

In the district of Nyarugenge, important civic buildings, commercial establishments and high-end bungalow areas are developed on the top of Nyarugenge hill. However, densely packed informal housing settlements sprung up on the slopes to the west of the hill, mostly housing people attracted by the employment opportunities in Nyarugenge. In 2005, the city expanded its urban limits, where by large rural areas came to be included within city boundaries.[59] The Taba group settlement is one such settlement which comprises of low income group families in the Kanyinya sector of this district.

**Water scenario**

In this area there is no municipal water supply nor is the use of ground water allowed. Families fetch water from a distance, in case of Taba settlement it takes residents approximately two hours to travel and draw water for daily water use activities. This settlement has a total of 28 families with an average of five members per family in 14 houses (twin sharing), with a water demand of 100 litres per day per family.

**Rainwater harvesting system**

The initiative of RWH system in this settlement was taken by RWFA in 2016 under the Rwanda's Green Fund (FONERWA).[60] The rooftop is used for capturing rainwater. A total of 3 interconnected ferrocement tanks have been installed underground with a capacity of 1000 $m^3$ each for storing rainwater. Inspection chamber present between the houses is used to maintain the velocity and flow of water. Also inspection chamber placed between the storage tanks is used to ensure rainwater is used from first chamber to second and then from third, respectively.

### Underground storage tanks

*Source: CSE, 2018*

The harvested water is used for the household purposes. Except for drinking for which they use tap water installed by WASAC or private operators. In extreme cases they use rainwater for drinking only after boiling it. However, after the installation of RWH systems they hardly face water problem.

**Operation and Maintenance**

A first flush system followed by sand filter of 1m depth is provided to avoid first one or two spells of season rainfall. As of now the catchment areas have not been cleaned. The tanks are cleaned once after the stored water is allowed to drain out through outlet drainage pipe and tanks are empty. The plan is to clean the tanks after every dry period.

In order to make the system sustainable it is important to provide proper sensitization of O&M to the households, so that it doesn't become a matter of concern in future.

### Filter system of the tank

*Source: CSE, 2018*

**Socio-economic and environmental benefits**

Overall, rainwater harvesting intervention in the settlement has been viewed as a practice that is socially acceptable and promotes self-sufficiency. The system has contributed towards convenience/ease in water accessibility and usage. The project has boosted the adoption of rainwater harvesting systems among households within this area. There is also reduced runoff from homesteads and reduced water logging around homes.

The installation of RWH system has not only provided social and environmental protection but also economical as the community is selling the harvested water to the neighbourhood households to generate income (20 L of water is sold for 20 RWF). The money collected is put into a cooperative and is used if any family requires for emergency or for O&M of RWH system.

'People have organized themselves and know the value of water, However, capacity building and sensitization of the group is required as O&M will be a challenge'
*Alphonse Rwagasana, Kanyinya sector/ agronomist and natural resources officer*

'We were facing lot of water problem, had to travel for 2 hours to get the water. After RWH system we are not only socially protected but also generate revenue by selling the water'
*Residents of the housing settlement*

This system is an example of how community involvement is essential for the sustainability of the system. Also it showcases a workable business model, which can be adopted by neighbouring settlements to attain a prudent water management society.

**Conduit pipes from roof top to horizontal channel as conveyance system**

*Source: CSE, 2018*

# 5 Challenges, Opportunities and Potential of Rainwater Harvesting

The RWH case studies documented in this report after conducting field surveys, KIIs and FGDs indicate the importance and benefit of RWH. However, there are some challenges which need to be addressed and deliberate efforts have to be made in order to scale up such practices. On the basis of the case studies assessed, the key challenges found are divided into various parameters listed below:

| | Key issues and challenges |
|---|---|
| **Legal and institutional framework** | **1. No status report or data available to showcase the enforcement of law to implement RWH**<br>Although as per article 11 of Law No 20/2011 of 21/06/2011 governing human habitation in Rwanda, states: Obligation to put in place a water collection and drainage system in urban areas. However, there is no data available to monitor the present status of enforcement. |
| | **2. Lack of coordination between state and nonstate stakeholders**<br>The various organizations in this sector are working in silos. More collective engagement between various institutional agencies and nonstate stakeholders is required for scaling up the initiative of RWH. |
| | **3. Majorly the RWH systems are implemented by individual users/owners**<br>As regard to public buildings, a feasibility study of 'Rainwater collection systems on Public buildings in Kigali city and other towns in Rwanda' was conducted by MININFRA in 2010. The study classified public buildings into 3 categories: 23 buildings (2.9%) were classified in category 1, 390 buildings (49%) in category 2 and 383 buildings (48.1%) in category 3. The report showed that nearly 74% of public buildings do not have any RW collection system and 24% of them had partial RWH system, leaving a minimal 2.4% equipped with such RWH systems. |
| **Social aspect** | **1. Technical knowhow of the RWH structures and technologies is minimal**: As per KII with officials from MININFRA, RWFA and with practitioners who were involved in implementing the showcased BMPs in Kigali, there is not much technical knowledge and skills available to implement RWH as per the site conditions. |
| | **2. Documentation of best management practices of RWH systems is absent**<br>There is no inventory prepared to showcase BMPs implemented in urban areas of Rwanda for reference or/and encourage further dissemination of such RWH practices. |
| | **3. Lack of research on importance and use of RWH for non-potable purposes in Rwanda**<br>As per KII with Professor from University of Rwanda, there is a need of detailed research and capacity building programmes to be conducted on RWH as an alternative source of water in urban areas. Provision of such studies and programmes may help in creating more awareness among the architects, planners and developers working in urban settlements. |
| | **4. Resistance among people to use harvested rainwater as an alternate source of water**<br>During the field survey, it was observed that hotels like Serena, Lemingo, Mille Collines and Umabano do not use the approach of RWH for an alternative source of water supply in spite of having a high water demand. Even the universities and schools like CMHS–REMERA campus–University of Rwanda are not able to spread the value and impact of RWH concept inspite of it being implemented at the site. KII with practitioners involved in RWH implementation projects revealed that due to absence of small scale filtration systems available in the market, rainwater is not considered safe source of water even for less potable uses. |
| | **5. Negligible community involvement/engagement for implementing RWH systems**<br>Although there are few examples of community initiatives in implementing RWH system for a neighbourhood like in Taba housing, it is essential to create and encourage more of such models, so that there is ownership by the user making the system sustainable. |

| | |
|---|---|
| Operation and Maintenance | **1. Provision of sustainability of the RWH systems in terms of operation and maintenance is lacking**<br>It is observed in the documented case studies that, O&M part of the RWH design is neglected. Due to less consideration to this aspect, the overall sustainability of the system is effected and leads to inefficiency of the system. Also, the presence of filtration material (like sand, pebbles) is not a usual practice. Further, during the survey it was observed that the staff involved in O&M are unaware of formal process of regular monitoring of the system.<br>**2. Prevalence of first flush is not a common practice**<br>A first flush is a device that is designed to protect RWH storage system from contamination by first flush runoff. Absence of this arrangement in RWH system leads to a lower quality of water captured with silt accumulation over time. As per the observation from surveys to selected case studies, there is no such knowledge among stakeholders to install/design the same.<br>**3. No quality analysis is done**.<br>As per surveys conducted to selected sites, there is no formal provision to monitor the quality of collected water. Only visual observation is done by the user to judge the quality of water. Simple observation—no odor, no color, no taste is done before using the harvested water.<br>**4. In cases where recharge of rainwater is practiced, groundwater depth is not monitored**<br>In Rwanda, not much data is available for groundwater as a resource, likewise, in case of small scale intervention, there is no data nor any provision to measure the water level depth and quantity of water groundwater resource available to create a water balance through RWH practice. |
| Funds/economic | **1. Availability of funds is a concern in practising RWH**<br>During the field survey, the practitioners and contractors showed concern regarding the incentives available for implementation of RWH system. Since implementation of RWH is environmental friendly initiative with high construction cost, they expect some form of subsidy or rebate in water bills. |
| Infrastructural aspect | **1. No alternative provision for water supply augmentation**<br>• Although many households in urban areas of Rwanda suffer from inadequate and irregular supply of water (2–3 times a week), majority of households in the cities do not practice water supply augmentation using RWH system.<br>• Most public investments in the water sector in Rwanda have focused on water supply infrastructure based on centralised systems using energy as major component. There is no major budget line dedicated to RWH in the National budget especially for rooftop water harvesting at household level and public buildings.<br>**2. Lack of adequate storm water management infrastructures**<br>• It is observed in urban areas of Rwanda, that there are common drainage channels for storm water and waste water which leads to overall polluted water quality of runoff.<br>• The urban areas with steep slopes suffer from soil erosion during high intensity rainfall.<br>• There are no provisions for water retention structures or SUDS to reduce and accommodate high peak runoff |

## 5.1 Proposed road map

Strong leadership and coordination would be necessary for a successful wide-ranging RWH implementation project. In addition, a coordinated educational programme will have to be conducted to dispel myths about stored water and to create the required skills base. The statutes and bylaws regarding water would also have to be reviewed to avoid legal impediments.[61]

The multi-layer institutional model requires substantial initial investment and effective communication between organizations, water users and governments. These included:

### 5.1.1 Legal and Institutional Framework

Although RWH as one of the provisions and initiative has been mentioned in policies, the on-ground implementation is still not enforced because of the following issues:

1. **Develop robust RWH guidelines:** Absence of RWH guidelines and norms as per building type/landuse, site conditions and purpose of harvested water use. One can refer to the 'Indian Standard Roof Top Rainwater Harvesting – Guidelines'[62], 'Guidelines and Manual for Rain Water Harvesting in Maldives'[63] for understanding the components required to draft a guideline. Moreover, it should be made accessible to all.

2. **Demarcated roles and responsibilities within Government bodies:** At present few of the tasks are not clearly defined. Various responsibilities like pre-assessment of the site, monitoring and testing as few of the major components of successful implementation are neglected by the agencies.

3. **Strong coordination among Government organisations:** There is lack of coordination among different government organisations working like Rwanda Housing Authority under MINFRA, Ministry of local Government, City of Kigali, Ministry of Health and Ministry of Education etc.

   To ensure convergence, it is mandatory that concerned ministries should meet and discuss the issue of water resource management. There needs to be a deliberate effort for a constant stakeholder involvement for promotion and dissemination of RWH as an alternative water resource in urban areas.

4. **Procurement and capacity building of human resources:** The existing government bodies like Rwanda housing authority, RWFA, MININFRA who are responsible for projects related to RWH for resource management are facing several issues of inadequate human resource and lack of technical know-how of the subject. Due to these issues many components of RWH are ignored.

5. **Provide different schemes to cover incentives**: In order to scale up and have a buy in for RWH systems among citizens it is important to provide incentives. For example, there could be a discount on water bills or provide rebates to procure material for implementation of RWH system by households. In India, various municipal corporations are offering concession of property tax in exchange of a rainwater harvesting system. In many cases authorities are penalizing the household by providing new water and sewer connections are provided only after the implementation of rainwater harvesting systems.

RWH is not given due credit. Policy talks about it, but enforcement is lacking. It should start from government buildings, offices, schools, institutions, health centres and the practices should be replicated at household level. So that these buildings demonstrate how policy is been enforced. Other aspects like awareness, sensitization, using techniques are also required. Also coordination between different organisations (MININFRA under which is RHA, ministry of local government, civil society, network of engineers, Kigali city, private sectors, ministry of health, ministry of environment, and ministry of education) is lacking.
*Maurice Kwizera, Country Director, WaterAid Rwanda*

"In the past, Rainwater has not been one of the main focus of government - It's gaining importance now. Rainwater is written in law but not enforced. Need to come out with guidelines which cover all the aspects of RWH."
*Ms Alice Umugwaneza, Director, Inspection and Audits Unit, Rwanda Housing Authority*

'Due to shortage of staff, there is little or no inspection on RWH systems being done'
*Ms Alice Umugwaneza, Director, Inspection and Audits Unit, Rwanda Housing Authority*

'Lot is in the policy, but implementation is lacking due to which demand is less.'
*Desire Kayigamba, General Manager—Projects, Synergy Pvt, Rwanda*

### 5.1.2 Socio economic aspects

Rwanda has a huge potential of RWH, however it is not fully recognized nor used to its full capacity because of the following social and economic issues at different levels.

1. **Creation of demonstration sites:** There is need of creating best management practices, case examples and pilot projects which can be referred by builders and contractors working in Kigali city. During the field survey the contractor of Vision city housing complex (General Manager of Projects, Synergy Pvt) mentioned that he was unable to refer any BMP or pilot project for proper designing and planning of RWH system.

2. **Capacitate and sensitize various stakeholder:** Government agencies as well as non-governmental organisations should come forward for capacitating state and non-state practitioners about the concept, design and techniques of RWH. There is a need of providing consultancy, handholding and training programmes not only to the engineers, architect, planners, academicians but also masons and plumbers—who are the real implementers of the project.

> One, quality is a worry among people thus many are hesitant to use it as an alternative source of water. Second, limited manufacturing companies are available in the city. Third, limited technology is present, which is not disseminated, approved and validated.
> SINDIKUBWABO Felicien, Executive Director, *Green Rwanda Organization*

> 'Importance of RWH is though only during crisis. Increase awareness and sensitization is required. The current water resources are not sufficient, government is looking at RWH as an alternative source.'
> *Official from Ministry of Environment, Kigali*

> 'At present for Kigali city, water supply is not 24x7 by WASAC, due to the problem of last mile connection and existing network system is old and needs to be updated.'
> Need is to have an alternative resource.
> *-Ms Kayitesi Marcelline, Water and Sanitation Division Manager, MININFRA*

Skill based training is required for implementers as the knowledge on specific design criteria for low cost tanks and the use of the stored water for non-potable purposes is generally lacking among building contractors.

> Little research has been done on RWH especially on the quality aspect.
> *Prof. Francois Naramabuye, School of Agriculture and Food Science, University of Rwanda.*

3. **Increased research and information required:** Measures at institutional level (university and schools) needs to be taken to facilitate and incorporate the RWH concept and approach under their existing course curriculum. With growing demand for water supplemented to high population density one needs to sensitize and aware the masses about new innovative sustainable technologies.

4. **Capacity building for improved awareness**: Further organising workshops, trainings related to RWH for students and teachers so that institutes promote and implement green intervention (if funds available).

> New Architects studying in KIST need to be sensitized, instructing architect to design RWH system in the drawings. We need efforts via sensitization to students and public (multimedia). Also inspections should be done
> *Eugene Pascal, General Manager, Mille Collines Hotel*

5. **Establishing sustainable funding channels for continued support:** For sustainability of RWH government has to take few measures:
   - Provision of funding and support from government to public and private sector should be initiated. Promoting RWH as a business; making RWH systems more accessible to the general public by government providing tax rebates and other incentives for dealers in system components; and undertaking persistent and consistent advocacy on RWH.
   - Joint efforts by all national stakeholders including engagement with foreign partners are needed in order to up-scale RWH and enable the technology to make a real difference as a climate change adaptation strategy for the country.
   - Develop an enabling environment by adapting best governance practices from comparable countries while addressing specific drivers and barriers in the Rwandan context.
   - Smart and safe RWH solutions via simple means. Develop sustainable and safe RWH solutions as pilot/model projects tailored to the rainfall, needs, and resources in a more peripheral and vulnerable communities with limited infrastructure.

Construction of RWH systems is not affordable and is expensive. New estates coming up are having RWH but it is mostly optional. *Bonny Rutembesa, Executive Secretary, Institution of Engineers Rwanda*

'People who cannot afford storage system, construct pits to drain the water as it is in the law that one cannot hold water in his property neither damage neighbours property. If subsidiary, incentive is given things can change. FORNERWA – green fund they did a great job in supporting tanks to poor people'
*Maurice Kwizera, Country Director, WaterAid Rwanda*

6. **Create demand for RWH to the society:** In order to create acceptance and demand of RWH in society following measures can be adopted
   - Awareness programme concerning the concept of RWH should be target based to meet the different levels of society. For high income group the focus could be on the environment to reduce flooding and erosion, along with available option to encourage the use of harvested rainwater for flushing, watering of lawns. For the low-income groups, the focus could be on affordability.
   - Introduce strategies to implement RWH at community level. The shift towards more community-based approaches and technologies, which emphasize participation, ownership and sustainability.

'MININFRA considers rainwater as a resource but not primary, use it for non-potable purpose.'
*Ms Kayitesi Marcelline, Water and Sanitation Division Manager, MININFRA*

7. **Creating an enabling environment for implementation of RWH systems**

- Establish knowledge products with support of relevant stakeholder. Make step-by-step guide providing all the details of planning, design, costing of RWH components as well as checklist and detailed know how of O&M for making the implemented system sustainable.
    - Ensure the regular monitoring and evaluation of the implemented RWH systems by the government agencies.
    - Establish information centres (like rain centres, exhibition centres) to know about RWH and its benefits. The centres can involve and bring together key players within the sector through workshops and more day-to-day consultations about RWH policies and techniques, water source mapping, water quality testing etc. The centres also play a central role in learning and knowledge exchange, systematizing best practices and experiences.
    - Create public awareness in view of water scarcity, it is important that the public be made aware of the present and future scenario of water shortage. Encouraging their participation in remedial action is crucial in implementing various interventions in this regard.
    - To raise the awareness of stakeholders and ensure that their voices are heard, the decision-making process needs to be participatory, with clearly outlined roles and responsibilities. Proactive public outreach initiatives, such as publications, public announcements and site visits are some means to secure wider public acceptance and support.
    - Capacity-building through continued RWH cluster development. Strengthen and develop RWH business through continued network-building, joint research and development with local as well as international partners, and knowledge transfer and development emanating from the established RWH cluster.
    - Initiate the process of involvement of various stakeholders including the community for implementation of RWH at national level
    - Encourage the use of local material for installation of RWH system and low-cost filtration system.

> Many stakeholders know what RWH is and its importance but implementation is lacking. Even if buildings have RWH structure but sizing of tanks is a problem. May be cost is an issue, its not estimated well. RWH systems are costly and need to be thought through and budgeted for while during the BOQ of buildings. If not budgeted then people simply make gutters and drain it in local drain.
> *Maurice Kwizera, Country Director, WaterAid Rwanda*

### 5.1.3 Environmental aspect

One of the most serious environmental problems facing the world is soil erosion. Among the major continents, Africa ranks second in the severity of soil erosion after Asia and Rwanda is among the 22 countries severely affected by soil erosion.[64] Kigali city is built on hills, ridges and valleys, the land is vulnerable to erosion and flooding.[65]

According to article 11 of Law No 20/2011 of 21/06/2011 governing human habitation in Rwanda, it is mandatory to put in place water

> 'RWFA wants to promote RWH nationwide as it will help to reduce floods and be a supplement of water used for non-portable water.
> At present most of the households and commercial properties have just the gutters and the water is drained into the local drainage system.'
> *Francois-Xavier TETERO, Head of Water Resources Management Department, Rwanda Water and Forestry Authority, Rwanda*

Residential areas construct usually pits to avoid water logging and to reduce erosion. *Bonny Rutembesa, Executive Secretary, Institution of Engineers Rwanda*

collection and drainage systems in urban areas.[66] Thus in order to prevent soil erosion, one can't hold water in his property neither damage neighbours property. In this connection many owners simply construct pits to ensure no water logging or damage of their property nor of their neighbours happens. The water passes through the pits to the local stormwater drains. This practice is prevalent mostly at institutional scale in Kigali where commercial properties like hotels do not capture rainwater but drain in out of their property. During the field survey it was observed that hotels like in Nobleza, Serena and Lemingo etc follow the practice.

Ideally this water should be harvested, as it would not only prevent soil erosion but also help prevent flooding during severe rainfall events, also on other hand it could be a viable solution to reduce water shortage. During the survey it was noticed that not only the hotels but also schools like GS Kabusunzu, Lyce Notre Dame de Citeaux as well as Remera health centre, University of Rwanda having huge land area only practice rooftop RWH. If RWH systems are implemented to their full potential at various scale, few of the multiple environmental benefits will be as follows:

1. **Flood management:** Extensive use of RWH will lessen the amount of urban run-off into the drainage and sewer system and hence lessen run-off load. In addition, by reducing run-off load, RWH will contribute to the reduction of flooding risks.

2. **Controlling pollution content:** RWH provide a means of managing and treating urban pollution before returning it to waterbodies.

3. **Meeting water efficiency targets:** Rainwater can have a major impact on water supply and is able to reduce municipal water demand by acting as an alternative source for non-potable water within domestic and commercial settings. This can be practiced at any scale. Case studies like Zion temple celebration, TVS Sameer Hussein have the potential to harvest more rainwater than the amount harvested at present to meet their water supply needs.

4. **Additional recharge of aquifers:** RWH provides a route for recharge thus helping to make savings on new water resource investment. Harvesting of surface runoff can help in recharging the aquifers. During the field survey it was noted that this practice was partly practiced in Akagera motors and TVS warehouse.

5. **Enhancement of biodiversity:** RWH helps in creating the micro climate, retaining water that will attract wildlife, creating stable habitats and providing corridors along which wildlife can move.

6. **Effect of climate change:** RWH can help to mitigate climate change as many of the cities experiencing floods and heavy rains are the same ones that experience seasons of drought.

# Annexures

## Annexure 1: Detail of stakeholders interviewed

| | |
|---|---|
| 1 | **Ms Kayitesi Marcelline,**<br>Water and Sanitation Division Manager, MININFRA<br>Email: marcelline.kayitesi@mi |
| 2 | **Ms Alice Umugwaneza,**<br>Director, Inspection and Audits Unit, Rwanda Housing Authority<br>Email: alice.umugwaneza@rha.gov.rw |
| 3 | **Bonny Rutembesa,**<br>Executive Secretary, Institution of Engineers Rwanda,<br>3rd floor of NOBSCUM House Remera, Near Chez Lando, Kigali<br>Email: engineersrwanda@gmail.com, rutembesab@gmail.com |
| 4 | **Francois-Xavier TETERO,**<br>Head of Water Resources Management Department,<br>Rwanda Water and Forestry Authority, P.O BOX: 7445 Kigali<br>Email: ftetero@gmail.com |
| 5 | **Maurice Kwizera,**<br>Country Director, WaterAid Rwanda<br>Email: MauriceKwizera@wateraid.org |
| 6 | **Prof. Francois Naramabuye,**<br>School of Agriculture and Food Science, University of Rwanda.<br>Email: naramabuyefrancois@gmail.com |
| 7 | **Desire Kayigamba,**<br>General Manager – Projects, Synergy Pvt,<br>Email: desire.k.rwd@synergyind.com, www.synergyind.com |
| 8 | **Eugene Pascal,**<br>General Manager, Mille Collines Hotel<br>Email: Pomec1@milliecollines.rw |
| 9 | **SINDIKUBWABO Felicien,**<br>Executive Director, Green Rwanda Organization<br>Email: sindikubwabo2012@gmail.com |
| 10 | **MUSABYIMANA Alexis**<br>Water Storage Development Officer<br>Rwanda Water and Forestry Authority<br>Department of Water Resources Management<br>Email: alexis.musabyimana@rwfa.rw |
| 11 | **G Stevens,**<br>Estate Manager, Akagera Motors |
| 12 | **Murinda Joseph Eric,**<br>Principal, GS Kabusunzu Secondary School |
| 13 | **Helen Nayituriki,**<br>Headmistress, Lycée Notre Dame de Cîteaux Secondary School |
| 14 | **Nkurunziza Samuel,**<br>Principle, GS Kagarama, Secondary School<br>**Email:** Samnkuru1975@gmail.com, KAGARAMASEC@YAHOO.COM |
| 15 | **Nzabandora hildebrand**<br>Principle, GS Akumunigo, Secondary School<br>**Email:** nzabahi@yahoo.fr, GSAKUMUNIGO@YAHOO.COM |
| 16 | **Hategekimana Christian,**<br>Estate Manager, University of Rwanda, CMHS-Remera Campus<br>Email: MUCHYKELLY@GMAIL.COM |

| | |
|---|---|
| 17 | **Niyibizi Venuste**,<br>Maintenance Technician, BPR<br>Email: Niyibizi.venuste@bpr.rw |
| **18** | **Ishami Karamaga Steve,**<br>Property Manager, Akagera Motors<br>Email: Steve.i@abgafrica.com |
| **19** | **Ritesh Patel,**<br>Managing Director, UTEXRWA<br>Email: utexrwa@gmail.com |
| **20** | **Muzungu Christian,**<br>Administration Division, Remera Health Centre<br>Email: csremera@gmail.com |
| **21** | **John,**<br>Manager, PT Executive Car Wash |
| **22** | **Faraz Bhagat**<br>TVS Warehouse<br>Email: F.bhagat@yahoo.com |
| **23** | **Estate Manager,**<br>Hotel Nobleza |
| **24** | **Alphonse Rwagasana,**<br>Kamyinyo sector/Agronomist and Natural Resources Officer,<br>Taba Grouped Settlement<br>Email: rwagasanalpe@gmail.com |
| **25** | **Clement Ndungutse,**<br>Water Engineer<br>SNV<br>Email: cndungutse@snv.org |
| **26** | **Kananga J Damascene,**<br>Water and Sanitation Officer<br>Bugesera District<br>Email: domoscenikana@gmail.com |
| **27** | **Gemma Maniraruta,**<br>Water Supply Development Project Implementation Officer<br>WASAC, Rwanda<br>Email: manirarutag@gmail.com |
| **28** | **Eng. NIYIDUFASHA Gilbert,**<br>Ground Water Officer<br>Rwanda Water and Forestry Authority<br>Email: niyert2009@yahoo.fr |
| **29** | **Fidele Tuyisenge,**<br>Civil Engineer<br>City of Kigali<br>Email: ftuyisenge@kigalicity.gov.rw |

## Annexure 2: Roundtable meeting on "Potential of Rainwater Harvesting in Urban Rwanda"

Centre for Science and Environment (CSE) conducted a roundtable on 'Potential of Rainwater Harvesting in Urban Rwanda' on 27th March, 2019 at Kigali, Rwanda. The aim of the meeting was to review the applicability of rainwater harvesting (RWH) as one of the potential measures for sustainable water management in urban areas of Rwanda.

A total of 23 stakeholders from 17 organisation attended the meeting. Participants included officials from RWFA, Ministry of Infrastructure, Ministry of Agriculture, Rwanda Environmental Management Authority, Donor Agencies, Advisors and representatives of key Non-Governmental Organizations working in water sector.

The stakeholders actively contributed and highlighted the challenges like poor urban planning and stormwater management, need of advocating and awareness programmes, lack of research and baseline data to track the impacts implemented, absence of rainwater harvesting policy which is still in draft stage. Few of the key questions discussed were: 'Is there enough political and regulatory push to support adoption of RWH in the country? What are they?'; 'What are the financial barriers that are preventing adoption of RWH?'; 'Are there enough benefits at user level, if they adopt RWH?'; 'What could be the elements of an enabling environment to support upscaling RWH at a country level?' The suggestions and comments of the stakeholders have been incorporated in the document.

Details: https://www.cseindia.org/roundtable-meeting-on-potential-of-rainwater-harvesting-in-urban-rwanda--9367

**Annexure 3: Water related Policies and strategies in Rwanda**

| S. No. | Policies and strategies | Key points | Provisions for RWH or Urban water management |
|---|---|---|---|
| 1 | Rwanda Environmental Policy (2003) | • Objective of the policy is improvement of human wellbeing, the judicious utilization of natural resources and protection and rational management of ecosystems for a sustainable and fair development.<br>• Lays a solid foundation for the establishment of a legal framework for improved management of the environment. | • Encourages programmes of rainwater collection, stocking and use. |
| 2 | Economic Development and Poverty Reduction Strategy 1 (2008–2012) | • The strategy gave priority to accelerating growth, creating employment and generating exports.<br>• The Water and Sanitation Sector's aim was to ensure sustainable and integrated water resources management and development for multipurpose use including increased access for all to safe water and sanitation services. | |
| 3 | National Policy and Strategy for Water Supply and Sanitation Services (February 2010) | • Focuses only on water supply and sanitation in close coordination with water resource management.<br>• It ensures that all water supply and sanitation projects and programmes abide by the relevant water resources and environmental laws of Rwanda defined by MINIRENA an REMA related to waste disposal and water extraction | • Rainwater collection at building level shall be promoted as another mean to decrease risks of runoff impacts and to increase water availability for hygienic purposes"<br>• Rainwater harvesting techniques and options (individual vs. collective) shall be studied, appropriate design guidelines shall be produced (for each climatic region of Rwanda) and pilot projects shall be launched and evaluated.<br>• Applied researches on innovation and technologies including on Rainwater harvesting as the main source of drinking water supply for areas that cannot be supplied by gravity. |
| 4 | National Policy for Water Resources Management (2011) | • Concerned with protecting and conserving the available water resources.<br>• Provides measures for managing water related disasters and stresses, arising from climate change, floods, droughts and demographic trends. | • Calls for the establishment of systems for enhancing water security by developing water storage and reservoir facilities and systems.<br>• Promote water conservation techniques and technologies, including RWH, water recycling and other appropriate technologies. |

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|---|---|---|---|
| 5 | Rwanda Green Growth and Climate Resilience Strategy (October 2011) | • Strategy attempts at plotting a climate resilient and low carbon development pathway for Rwanda.<br>• It aims to build upon work that is already being done in Rwanda on climate change, focusing the various projects and policies into a holistic national document.<br>• Under program 3 it focuses on the Integrated Water resource management and planning.<br>• It states that Rwanda will develop a National Water Security Plan to employ water storage and harvesting, water conservation practices, efficient irrigation, and other water efficient technologies. | • Highlights the need for water storage development and rainwater harvesting in the Integrated Water resource management and planning.<br>• Framework that incorporates district and community-based catchment management.<br>• Also one of the indicators under this programme of action is related to water storage per capita. |
| 6 | Economic Development and Poverty Reduction Strategy 2 (2013–2018) | • Under the strategy, the green economy approach favours the development of sustainable cities and villages.<br>• Focuses on water supply and sanitation under the priority of 'Improved infrastructure' aiming at universal access to safe water and sanitation by 2017/18.<br>• Aim to ensure that households across rural areas are within 500m of an improved water source. | • Identifies role of RWH to achieve the goal of EDPRS 2 of managing water resources according to IWRM approach. |
| 7 | Revised National water policy (December 2016) | • Aims for 100 per cent coverage of rural and urban water supply and 100 per cent coverage of household sanitation by 2020.<br>• Policy presents the sector's approach on how to achieve the Vision 2020, SDGs and EDPRS objectives.<br>• Also encourages and mobilizes private-sector investments in new infrastructure. | • Rainwater catchment systems will be promoted as a complementary source of water for both households and public buildings. Promotes RWH as a tool to provide access to safe and reliable water supply services for schools, health facilities and other public places along with tap water.<br>• An inclusive and holistic strategy for rainwater harvesting that will eventually lead to attaining national water security. |

**Annexure 4: Water related Plans, Programmes and Legal Provisions in Rwanda**

| S. No. | Plans, Programmes and Legal Provisions | Key points | Provisions for RWH or Urban water management |
|---|---|---|---|
| 1 | Vision 2020 Rwanda | • Government development program to attain long term development goals using 47 indicators and targets under 6 interwoven pillars.<br>• Under infrastructure development they aim for protection and efficient management of water resources and water infrastructure development to ensure that by 2020 all Rwandans have access to clean water | • Rainwater harvesting strategy is in line with the target of access to water for all Rwandans by 2020.<br>• Rainwater harvesting and water storage development will contribute to the achievement of this target. |
| 2 | National water resource management master plan (2015) | • The long-term 25 year masterplan that allows the identification and implementation of effective water supply and sanitation projects.<br>• It defines nine level 1 catchments and summarizes outstanding issues and recommended actions for each of the nine catchments.<br>• Focuses on protection, conservation, safeguarding and rational use of water resources. | • The issues and recommended actions for the catchments are mostly related to rainwater harvesting.<br>• Key areas for RWH include soil erosion control, livestock, irrigation ponds and water supply for domestic use. |
| 3 | Integrated Water Resource Management Programme (2016) | • IWRM is an internationally recognised approach to land and water resource management.<br>• It promotes the coordinated development and management of natural resources to maximise socio-economic gains without compromising environmental sustainability. | • To demonstrate the value of the IWRM approach, Water for Growth is working across the 4 catchments to pilot governance frameworks and develop water management solutions. |
| 4 | Law n°55/2011 of 14/12/2011 governing roads in Rwanda as amended to date Article 28: Water drainage system | Water from households and any other wastewater must not be directed to public road | |
| 5 | Article 11 of Law No 20/2011 of 21/06/2011 governing human habitation in Rwanda | It is mandatory to put in place water collection and drainage systems in urban areas. For the purpose of environmental protection, preservation and promotion, each urban human settlement area must be equipped with an adequate rainwater collection and drainage system that is in compliance with hygiene and sanitation legislation.[67] Following article 14, the same applies in each rural human settlement. The Ministerial Order N° 04/Cab/015 of 18/05/2015 determining urban planning and building regulations provides for guidance of storm-water management and soil erosion control measures. | |
| 6 | Article 67: Environmental Impact Assessment | Every project shall be subjected to environmental impact assessment, before obtaining authorization for its implementation. This applies to programmes and policies that may affect the environment. An order of the Minister having environment in his or her attributions shall determine the list of projects mentioned in this organic law. | |

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**This report documents rainwater harvesting (RWH) case studies in Kigali, highlights best management practices, and details its contribution to water augmentation and storm-water management in Rwanda.**

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